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Included in this publication are 16 papers related to teaching chemistry in junior colleges. The papers are presented in the following topic areas: (1) Instructional Systems: (2) Current Concerns in Chemical Education: (3) Learning Problems in Chemistry: and (4) Special Topics to Teaching. (SA)

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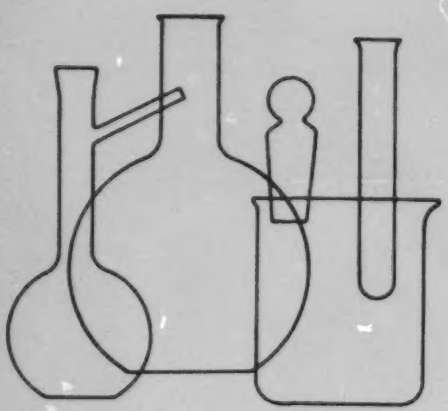

CHEMISTRY IN THE TWO-YEAR COLLEGE

VOLUME XVIII 1977

COMMITTEE ON CHEMISTRY IN THE TWO-YEAR COLLEGE
DIVISION OF CHEMICAL EDUCATION • AMERICAN CHEMICAL SOCIETY

SE 028 630

Foreword

As I was flying home from the Sixty-Third, Two-Year College Chemistry Conference in Columbus, Ohio, as often happens, my mind was filled with fresh ideas, renewed enthusiasm, pleasant memories of friendships, both old and new, and many other rewarding impressions. One part of these reveries, which has endured and grown through the years, is a feeling of gratitude for the many rewards participation in a genuinely professional organization brings.

Of course it takes professional people to make a professional organization. To me, being a professional chemical educator in the fullest sense, involves more than occupation and level of educational achievement. It involves, among other things, a willingness to make personal and financial sacrifices in an effort both to grow continuously in knowledge of the subject and ability to teach it, and to contribute to the profession.

Attending a professional meeting requires a sacrifice of time, energy and, in many cases, a considerable amount of money. Planing and conducting conferences, editing and publishing the journals, and performing the myrid of other tasks necessary for $2YC_3$ to function requires considerable additional sacrifice by many individuals.

When I consider the sacrifices made by conference speakers (many of whom have contributed to numerous conferences), who share their knowledge, talents, and expertise, without receiving even a token honorarium, and often at their own expense, I am amazed and grateful.

If we had to pay appropriately all the speakers, chairpersons, officers, committee members, and others for their contributions; the host institutions of the conferences for their contributions; and for all the typing, printing, mailing, and other incidental expenses of the organization, I think we would be astounded at the cost. Because I realize that I receive almost free of charge, benefits that I could not otherwise afford, I am extremely grateful for the opportunity to participate in $2YC_3$.

Since everyone cannot afford to attend all the conferences, it is indeed fortunate that this journal is available at a cost ($4.50 annual membership dues in $2YC_3$) everyone can afford. This journal and the Journal of Chemical Education provide invaluable avenues for professional growth at minimum expense and maximum convenience. Membership in $2YC_3$ does not require membership in ACS or the Division of Chemical Education, subscription to the Journal of Chemical Education ($10.00) does not require membership in ACS or the Division of Chemical Education, and membership in the Division of Chemical Education ($4.00) does not require membership in ACS.

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INSTRUCTIONAL SYSTEMS

Recent Attempts to Individualize Pre-Laboratory Instruction in Freshman Chemistry

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Presented as a part of a Symposium on Innovation in Communicating Chemistry at the Fifty-Third Two Year College Chemistry Conference, Brandywine College, Wilmington, Delaware, April 23, 1977.

The attainment of an effective level of laboratory instruction poses many interesting challenges to the instructor in that students are evaluated on manipulative skills, data acquisition and interpretive abilities. Laboratory courses are in a constant state of change as chemical journals report, each month, novel undergraduate laboratory exercises which are suitable for chemistry or non-chemistry majors. The most important characteristic, of a laboratory exercise lies in a student's ability not only to carry out the procedure but also to understand clearly the underlying theory which inherently dictates the experimental procedure. To simplify the transition that the chemistry student must encounter in putting classroom theory into laboratory practice, it is clear that chemistry educators should actively begin to share their ideas and concerns regarding the importance and nature of pre-laboratory instruction as an integral component of the undergraduate curriculum.

Pre-laboratory programs tend to vary in their scheduling formats and content emphasis. The most direct approach is the 20-30 minute lecture presented at the start of the laboratory period. Time limitations and class size usually preclude effective pre-lab demonstrations of the experiment or parts of it. A serious disadvantage of this instructional format is its infringement on scheduled laboratory time. As an alternative, actual course lecture time can be set aside for laboratory orientation each week. If a discussion of the laboratory exercise coincides with the first class meeting of the week, several days may elapse before students carry out the experiments in the laboratory.

The pre-laboratory curriculum that we have developed makes use of a common set of teacher-produced instructional materials which are used both by students and faculty in conjunction with a variety of media delivery systems. The focal point of media

supplementation for these pre-laboratory programs involves the preparation of highly registered 35 mm slides for use with two slide projectors connected to a dissolving unit. The delivery technique, known as Lap-Dissolve Projection (1-6) has continued to grow in its acceptability as an effective means of demonstrating chemical concepts through animation. However of primary consideration in this context is the expanded use of the same visual Lap-Dissolve materials to prepare self-pacing instructional programs that students may use at any time prior to their scheduled laboratory period.

The quality of visual materials produced by individual teachers can vary tremendously, the principal criteria here being visual appearance rather than content or programming. However, as a means of minimizing the time lag between concept and implementation of programs, we have found it to our advantage to produce our own programs, either as individuals or with the assistance of interested undergraduate students. Clearly, one of the benefits of self production is simply that it forces the teacher to look at the problem of communication in a new way. Our experience has been that not only are good quality visuals quite easy to prepare but overall costs decrease considerably as compared with the usual campus media production services.

The majority of the pre-laboratory programs that we have developed apply to high enrollment introductory non-chemistry majors courses. Students have been very receptive to the use, contents and accessibility of the programs. However, the question of quantitative effectiveness of these materials in enabling students to learn and comprehend ideas easier still needs to be answered.

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Personalized Teaching for a Class of Thousands — The Learning Systems Approach

Rod O'Connor
Larry Peck
Texas A&M University
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Presented to a session on Personalized Systems of Instruction at the Fifty-Third, Two-Year College Chemistry Conference, Delgado Community College, New Orleans, Louisiana, March 19, 1977.

The use of learning objectives, alternative learning resources, positive-attitude factors, and future-oriented course content can result in significant improvement in learning, as measured by performance on cumulative examinations and in subsequent higher level courses. An extensive study of the Learning Systems Approach in a very large general chemistry program reveals some major advantages for both students and teachers.

The Learning Systems Approach to the teaching of first year college chemistry for science-oriented students was initiated in 1968 and has now been class-tested at a number of colleges and universities. At Texas A&M University, the method has been used since 1973 with a general chemistry course of 3000-4000 students per semester. The Texas A&M program is considered "personalized", rather than "individualized", since it provides a personal choice of learning resources within fixed time constraints, rather than the self-pacing typically associated with "individualized" programs. This course is now one of the most popular on campus, although the majority of students claim that the program actually requires more effort than other science and mathematics courses. About half of the students complete the two-semester program with A or B grades and students from this group are found to perform significantly better in subsequent chemistry courses than A and B transfer students from 113 other institutions studied. The key to the success of the program is the cooperative effort of a large number of faculty in using common learning objectives and equivalent objective-based examinations.

LEARNING OBJECTIVES In our program we use a textbook, supplementary problems book and laboratory manual that contain sets of learning objectives. Selection of the specific material for which students are responsible is indicated in the form of a Paced-Learning Calendar (Figure 1). We divide specified objectives into those of "short-range" importance, requiring only completion of a one-time homework assignment, and those of "long-range" importance, requiring achievement measurement by examination. The latter set is identified in Study Guides distributed at 3-4 week intervals during the semester. The Study Guides further differentiate long-range objectives as competency level (expected of all students) or proficiency level (expected of A and B students). Our experience indicates that our use of learning objectives and the study-time scheduling of the Paced Learning Calendars has had a measurable impact on learning efficiency.

CHEM 102 PACED-LEARNING CALENDAR January 1977

SUN	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
	17 *Lecture:* SPECIAL TOPICS	18 homework: Review Unit 19 (T: pp. 289-302)	19 *Lecture:* EQUILIBRIUM REVISITED homework: Exercises & Self-Test (T: pp. 301-302)	20 homework: READ Unit 16 (T: pp. 255-265)	21 *Lecture:* SOLUBILITY EQUILIBRIA homework: Exercises & Self-Test (T: pp. 264-265)	22
23	24 *Lecture:* K_{sp} APPLICATIONS homework: PB: Unit 10	25 homework: READ Unit 21 (T: pp. 323-335)	26 *Lecture:* ACIDS & BASES homework: Exercise 1 Supl. Ex. 1. Self-Test 1 (T: pp. 336-337)	27 homework: Complete Exercises (T: pp. 336-337)	28 *Lecture:* WEAK ACIDS & BASES homework: Complete Self-Test (T: p. 337)	29 homework: READ Unit 22 (T: pp. 329-348)
30	31 *Lecture:* BUFFER SYSTEMS homework: Exercise 1, Supl. Exercise 1 (T: p. 348)	KEY: T = Textbook (Fundamentals of Chemistry) PB = Problems Book (Solving Problems in Chemistry)				

Figure 1. Sample Paced-Learning Calendar for the second semester of the program, with lectures beginning January 17, 1977. All sections of the course follow a common schedule of lecture topics, although each lecturer is free to discuss the topics in his own way.

ALTERNATIVE LEARNING RESOURCES

We recognize that students learn in different ways[4] and at different rates. Since we do not provide a self-paced option, the differences in learning rates require some students to use more study time per day than others in order to reach desired achievement levels. We encourage all students to investigate our alternative learning resources and to develop a study pattern best suited to their own unique needs.

For some students, particularly those with superior backgrounds in science and mathematics, the combination of textbooks and laboratory experiences with periodic, informal group review sessions may be sufficient to permit achievement of learning objectives. Most students, however, supplement these resources by attending one or two of our lecture sections, by utilizing various programs in our Autotutorial Learning Center, or by working individually with faculty in our Professor-Tutorial Program. The majority of our students rather quickly develop their own personalized mixture of these various resources as determined by their interests, available time, and individual learning modes.

Our program may well be unique among multisection courses in offering students freedom of lecturer choice. In the fall of 1976, for example, we offered seventeen sections of the "onsequence" course. Students were assigned to a particular section for examinations, but were free to "shop around" among the seventeen sections for the particular lecturer whose content emphasis, level of approach, and lecture style they found most effective. As a result, some sections had an average attendance of 15-20 (permitting highly interactive sessions, rather than formal lectures) and other sections (in a 330 seat lecture hall) had students sitting in the aisles and standing in the back. Although lecture attendance was optional, most students attended the lecture section of their choice on a regular basis and many students attended two different sections to profit from alternative approaches to concept development and problem-solving.

Our Autotutorial Learning Center, open about 45 hours per week, provides access to a variety of supplementary readings, programmed-instruction materials, old exam files, tape/workbook and slide/tape programs, and an extensive collection of Super 8 films. Both commercial[5] and locally-produced[6] programs are used. Student utilization of this Center has been so extensive that a new 130-station Center has been constructed for occupancy in the fall of 1977 and many of our programs are being converted to microfiche formats for less expensive multiple copy production.

For students feeling the need for individual work with faculty, we provide a Professor-Tutorial program, with office hours of volunteer senior faculty available at every hour of the academic day. Although only a relatively small percentage of our students use this program extensively, we consider it a major learning resource for students profiting from a one-to-one interaction with faculty.

POSITIVE-ATTITUDE FACTORS

It is our belief that factors that improve a student's attitude toward learning can have a significant effect on the student's efficiency of learning. All of the faculty and staff associated with our program are dedicated to demonstrating a real concern and affection for students. Our freedom of lecturer choice, regular evening review sessions, and Professor-Tutorial Program have all been identified by students as major "positive-attitude factors". Even such "small" things as the distribution of answer strips at the end of examinations, the use of audio-visual aids, and the occasional injection of humor into lectures have received much favorable student response.

Very few of our students plan to be professional chemists, although our program is specifically designed to provide background for further study in the field. We have found that student attitudes to this type of course content are significantly improved by the extensive illustration of applications of chemical concepts and problem situations to other fields. We include many of these applications in lectures and we provide alternative problem sets

in the areas of biological and medical sciences, engineering and economics, and environmental sciences. Our laboratory program is relatively unique in using "real-life" situations as settings for chemical investigations. Such experiments as the conversion of waste aluminum cans to alum, the determination of water hardness, and the measurement of chemical oxygen demand in waste water samples are typical examples of "relevancy".

In the last half of our second semester, we divide the students into two "interest groups". One group spends several weeks studying topics related to organic and biochemistry and the other group spends most of this time on topics related to industrial chemistry and the environment. Students may choose to study with either or both groups.

Our examination and grading system has proved to be another positive-attitude factor. This system is, in fact, a key to our personalized program. All exams are prepared by the Program Director so that all sections have equivalent exams. Question formats are approved by participating faculty and 26 variations on each question are prepared on 5" x 8" cards. Each examination has twelve questions covering a set of objectives identified in the previous Study Guide. Using the question card file, eighteen forms of a 12-question exam can be prepared in about six hours. A coding system ensures that no two exams can contain the same set of questions, so old exam files can be made available to students as study aids for review. Grades are determined entirely on the basis of percentage achievement of specified objectives so students find diligent study rewarded and avoid the uncertainities and competition of a "grade-curve" system.

FUTURE-ORIENTED COURSE CONTENT

We believe that a first year chemistry course should be designed to provide adequate background for further study in the field. Since the next courses available to our students are analytical and organic chemistry, we plan our course content to prepare students specifically for these courses. We use the textbooks from these courses to determine appropriate background material and we employ a regular feedback questionnaire for faculty teaching analytical and organic chemistry to keep us informed of areas needing improvement or reinforcement as evidenced by student performance patterns. In this way we can ensure that the prerequisite character of our course is improved each year.

We include rather extensive treatment of such topics as thermodynamics and kinetics, primarily as background for modern organic chemistry, and these topics also provide useful material for further study in physical chemistry.

STUDENT EVALUATION

The results of student questionnaires show an overwhelming response that our program, in comparison with other science and mathematics courses, is the best organized, provides the best opportunities for learning, and shows the most genuine concern for students. The first semester of our course was considered by 43% of the students to be "harder than" and 30% "as hard as" their other science and mathematics courses, and our second sem-

ester was ranked by 51% to be "harder than" and 32% "as hard as" comparable courses.

One of the most gratifying results of student evaluations has been the very favorable opinion of our lecturers. Since students are free to attend the lecture of choice, it is evident that most students locate a lecturer they like to work with. Every one of our lecturers received 80% or better favorable evaluations in the fall or 1976 and faculty from our program have received teaching awards in both 1975 and 1976.

STUDENT PERFORMANCE

Since we initiated the Learning Systems Approach in 1973, approximately half of our students have completed the course with A or B grades. This is significantly greater than is usually found with more conventional chemistry courses. Since we counsel students to drop the course if they are not making adequate progress, our failure (F-grade) rate is less than 10%, but about 15-20% of our original students do drop. More than 70% of the students completing our course show greater than 80% achievement of long-range objectives, as tested by a comprehensive examination.

We consider the most important measure of success in our program to be the performance of our students in subsequent chemistry courses. If, as planned, our attention to "future-oriented" course content was appropriately designed, we should expect our students to perform better in subsequent courses than students transferring from other colleges having "conventional" general chemistry courses. Such, indeed, is the case (Figure 2). It is, perhaps, worth noting that these differences were <u>not</u> observed in pre-1973 grade data, prior to adoption of the Learning Systems Approach, except in the area of "passing" grades.

The differences in general chemistry backgrounds of students should be less obvious with final grade comparisons than with <u>midsemester</u> grade comparisons, since the course coverage itself should have some leveling effect on background differences. If our program, then, truly provides an improved background for analytical and organic chemistry this should be reflected best in midsemester grade data.

SUMMARY

We feel that the Learning Systems Approach is working very well with our large multisection general chemistry program at Texas A&M University. The combination of learning objectives, alternative learning resources, positive-attitude factors, and future-oriented course content has led to significant improvement in student performance and to increased learner and teacher satisfaction. Although some aspects of our program, such as the freedom of lecture section choice, may not be applicable to smaller programs, many parts of the program could be tried in almost any course. We would particularly recommend the general philosophy of the Learning Systems Approach, the continuing use of faculty and student evaluations, and the subsequent course performance

analysis to those faculty interested in improving the prerequisite character of their programs.

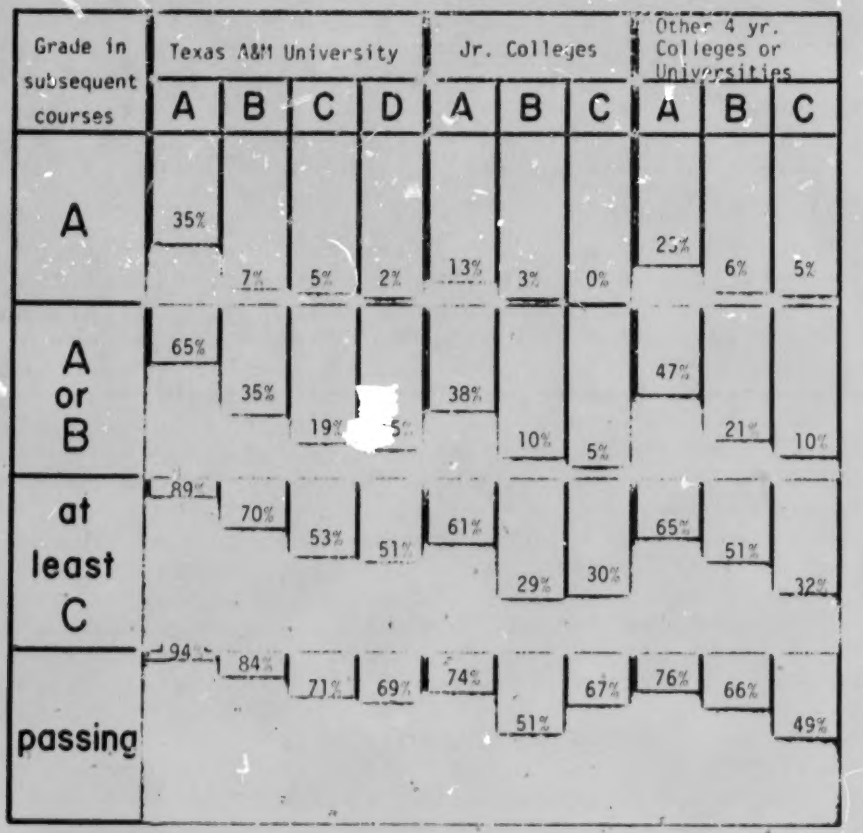

Figure 2 Prerequisite and grade character of first year chemistry, based on final grades from fall semester 1976 of 1353 students taking analytical and organic chemistry (including 352 transfer students). Note the consistent pattern of our students performing better than transfer students in every grade category. (Relatively few F grades were given. Most students "not passing" actually withdrew from the courses.)

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ACKNOWLEDGEMENTS

Our sincere appreication is expressed to Dr. A.E. Martell (Head, Department of Chemistry) for his support of our experimental program and to the members of our Divisions of Analytical Chemistry and Organic Chemistry for their suggestions and cooperation.

To a very major extent, whatever success our program has achieved is due to the magnificent efforts of the faculty participating in the teaching of our course. They have, indeed, demonstrated to thousands of students that "someone cares". Our very special thanks to Darrell Axtell, Alton Banks, John Beckham, Dwight Conway, Ed Crawford, Karl Gingerich, Kelly Gladden, Joe Ham, Alan Hart, Alton Hassell, Richard Hedges, C.A.J. Hoeve, Paul Javora, Jaan Laane, Jack Lunsford, Al Rodgers, Tim Rose, Mike Rosynek, Jerry Sarquis, Yi-Noo Tang, Dave Torgerson, John Villarreal, Rueben Walter, and Randolph Wilhoit

Evolution of an Audio-Tutorial General Chemistry Program

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Presented to a session on Personalized Systems of Instruction at the Fifth-Third, Two Year College Chemistry Conference, Delgado Community College, New Orleans, LA. March 19, 1977.

INTRODUCTION

The Audio-Tutorial program in General Chemistry at Clemson University was initiated in August, 1971, on a shoestring, with 100 students initially enrolled. Students were registered without knowledge of the type of course, but were allowed to drop or add the course if it suited them.

The course was designed after the Biology program at Purdue University (Postlethwait, 1972) with minor variations to suit the needs of our students and the topic of General Chemistry.

The course structure includes:

1. General Assembly - all students meet together for 1/2 to 1 hour for discussion of special topics, problems with the system, or for general stimulus. A book is provided for student comment during the week - these topics are periodically discussed, also.

2. Quiz Sessions - (A) A half-hour written quiz, usually objective, is given per week. This instant feedback provides for revisions and improvement of learning materials and policy. (B) Oral quizzes of 1/2 hour, with 10 students per session, are given weekly. These are done with instructor and students seated about a table. Student response has been overwhelming - "Orals are more effective for clearing up misinformation than anything we've ever done".

3. Independent Study Sessions - The Audio-Tutorial Study center is equipped with individual carrels with audio-tape players which are accessible to the student 40 to 50 hours per week.

The study center contains:

A. The study guide or "minicourse" is the core of the study session. This is a written package of material designed to be covered in one sitting of 2-4 hours by the student. (Allen, 1974a). It is designed with:

Prerequisites - what the student must be able to do before he studies this minicourse.

Objectives - what the student must do to satisfactorily complete this minicourse. (Mager, 1962)

Pretest - Allows the student to test his knowledge before and after studying the minicourse.

Body - Includes text, diagrams, activities, short laboratory experiments, all broken up by questions to enhance and reinforce the learning at the appropriate time, not just at the end as a review of the chapter.

In addition, some questions were designed to help the student "discover" chemical concepts and facts from his own past experiences.

Answers - Answers are provided to calculations, etc., which cannot effectively be covered by taped discussions alone.

B. Audio-taped discussions or tutorials (not lectures) about the topics covered in the study guide, in the voice of their instructor. Students are allowed to check out the cassette tapes for home study.

C. Visual aids - slides, videotaped demonstrations, movies, photographs, charts, tables, etc.

D. Tangible objects - These are objects which support the learning experience, such as molecular models or samples of chemicals. For example, while discussing malleability and ductility of metals, having the student handle one soft metal (Pb) and one stamped, Hard metal (a penny) reinforces these concepts in a simple and clear way.

E. Demonstrations - These may be brief hands-on type observations (e.g. relate the color and wavelength of light using a Spectronic 20) or more elaborate experiments (titrations, etc). The one purpose of the demonstrations or experiments is to teach, either technique or concepts more effectively and efficiently. No 3-hour experiment to prove a 15 minute concept!

F. Grading System - Grading was based on the mastery concept, requiring the student to make 75% on every quiz in order to pass with a grade of "C". If he did not make 75%, he was given one opportunity to make up that quiz. A grade of "F" was assigned if he did not pass every quiz. To make a higher grade, the student accumulated credit points by making a perfect score on weekly quizzes, by scoring high on three optional, cumulative exams, which went beyond the weekly objectives, or by doing extra reading or laboratory exercises. Superior lab technique in the regular experiments was also rewarded with points.

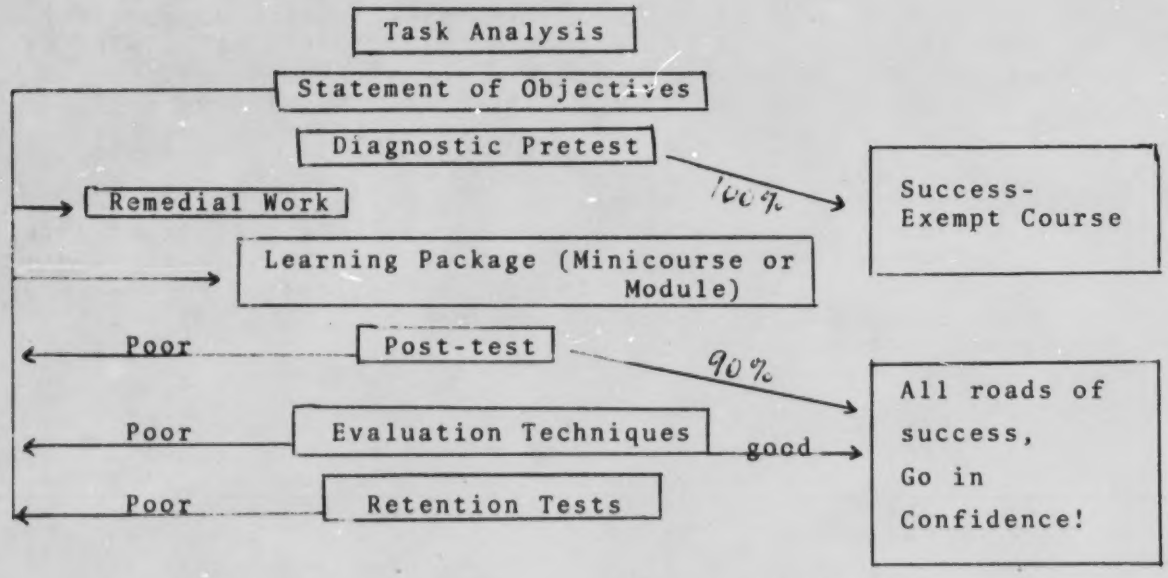
The General Chemistry course at Clemson University consists of two volumes, containing 26(Vol.I) and 23 (Vol. 2) minicourses, respectively (Allen, 1974a). These are covered at the rate of 1 to 2 minicourses per week, with an average of about 1.6.

Over the past six years we have slowly changed the course, sometimes with success and sometimes not. One advantage of a mastery based course with frequent quizzing is that we can identify those failures before they become disasters.

PHILOSOPHY

As scientists we should always seek to work in systematic ways. Unfortunately, our teaching is not always done systematically for several reasons, such as: our teaching load may be so large we have little time left over, our research demands a major portion of our time, etc. Thus we teach the "easiest" way, the way we were taught.

I suggest the following flow diagram as one approach to our teaching:



Next, we need to determine spheres of responsibility. The student has the responsibility of doing his best to learn what is expected of him, and to seek his own level of accomplishment and competence, but in the past we have saddled him with almost all the responsibility for his learning. We professors usually present lectures which may motivate the student and clarify the primary points, but the student was expected to learn most of the material from a text which is more reference book than learning guide. Now, a welcome change is occurring, we are becoming responsible for the student's progress, for supplying him with the best and most efficient means of accomplishing a given goal, with no hidden tricks to make us "weeders" rather than "gardeners" in teaching our specialities. Even the courts are beginning to check out our consistency! I'm afraid we can expect more of the same, since M.D.'s, lawyers, and others are being sued; what protects us from the same fate? We can require a certain level of accomplishment before we certify a student to go ahead--so the student has the responsibility to master the material we decide to require. If he doesn't master it, we can't throw him out as would a useless worn out left shoe, but we should let him recycle and learn from his errors until mastery is achieved.

Problems exist with mastery grading and recycling. I frequently hear the statement "Letting the student retake a quiz doesn't prepare him for the 'real world' in which he is expected to perform within a time frame". I disagree! My experience in the "real world" of business indicates that successful businessmen and scientists will test and retest a hypothesis or a major paper before presenting it as fact, making mistakes and correcting them before making public statements. Often, their employees and students are expected to submit material to them for checking (grading?), and revision before making it public. Can we as educators and scientists, ignore the "trial and error" method of

learning so casually? Even if this criticism were valid, it could be corrected by changing the nature of our stated objectives to include a time limit for the student - but "one try at 8 A.M. on Friday, May 10th" doesn't seem justified.

One real problem is that some view the use of objectives and mastery as limiting the learning of the student. This is true only if the professor uses it to limit learning, but if we reward the student for other desirable accomplishments, then he will go beyond the objectives. This is our justification for the grading system of a "C" grade for mastery, with accumulated points for an A or B.

Many examples exist where grading systems are very rigidly imposed, with the professor dictating to the student what must be learned. In recent years, some have tried to allow the student to set the standards for his learning. I believe both extremes to be poor judgment, and propose the following Rules of Relevance:

1. Little is relevant to him who has no choice.
2. Nothing is relevant to him who knows nothing.
3. Little is irrelevant to him who seeks.

From the first two of these, I suggest a third procedure for determining course content. The professor should set the minimum standards of competence required for passing a course, using objectives and mastery. Some time should then be allowed for the student to read, perform experiments, and to otherwise seek to satisfy his curiosity and interests about the topic.

Part of the grade should also be used to reward this extra work. For science and non-science majors alike, chemical education can be more effective and exciting if we encourage and reward reading of Scientific American, Chemistry, and such books as "Double Helix", Lawrence and Oppenheimer", "Future Shock" and biographies such as Ruth Moore's "Neils Bohr".

Thus, I see our "text" as being divided. One portion, the "learners text" should be developed to help the student achieve mastery of the stated objectives as quickly as possible. The second is the list of reading materials to be required or chosen as options by the student. In this way we assure the learning of the basic tools of chemistry while also having students read interesting, up-to-date science from magazine articles and recent science books. Thus, we clearly fulfill our basic obligations as teachers while also stimulating the student to try "relevant" ideas beyond those in a text which may be 3 or more years old

EVOLUTION

Although we have qualitative and semi-qualitative evidence (Allen 1975) that the program described has worked well, some portions left us uncertain. Therefore, we have tried the following changes, the effect of which is also described:

A. Grading: Passing has been increased to 80% on each quiz, with up to four attempts to pass a given quiz.

Results have been mixed. This has not increased the % who pass for it seems to have increased procrastination. It has decreased tension on a given quiz and allows the student more freedom to schedule study time when other courses are pressing.

We have tried several forms of major exams, with each having some advantages and some disadvantages. First, we used the "A-B" Exam concept described by Postlethwait. Three optional exams were given which go beyond the stated objectives. For example, these might be a synthesis of 2 or 3 objectives from different minicourses and would test the ability of the student to use the knowledge from small steps to solve bigger problems.

In an attempt to help the best prepared students, for a year we made the major exams comprehensive final exams on which the student could take any or all of the three times it was offered. It was given at the 5th and 10th weeks, then at the regular exam time. Grading was: Over 90% on any one of the exams and completed laboratory work earned an A in the course. Over 80% on any exam and completed laboratory work earned a B in the course. A "C" could not be earned by examination alone. Without the exam, enough points could be accumulated to give a B in the course. This procedure worked well for the very good student, but seemed to de-emphasize the exam for the majority.

Lately we have given a mid-term and a final exam, each with a grade scale which emphasized high performance. As an example, enough points could be earned by an exam score over 95% to guarantee an A in the course. This rewards the student who starts poorly, works hard, and masters the material. By exam time he is well prepared. This method seems to be working well, but we hope to test these students against a "standard" group to see whether it really encourages better preparation.

Oral quizzes haven't changed much. Students are scared at first, but find that these clear up misconceptions extremely well. The students insist on these as they learn to use them.

B. Minicourses: Several changes are under way. We have added supplemental minicourses for those specific areas which give some students major problems, such as % calculations, molecular geometry, etc.

Some of the better prepared students do not want to use audio-tapes because these students read well. We are revising all the minicourses to make the minicourse totally independent of the tape. The audio tape will then be used exclusively to tutor those who need help.

Testing the minicourses on students has also shown some areas which need more complete discussion. This is being added and will soon be tested.

Demonstrations and experiments are now given as "suggested" rather than "you should do", because some instructors in other schools preferred different experiments to prove the same point.

C. Laboratory: During the early semesters of our program, we minimized the laboratory work with emphasis on a few techniques and attempted to prove a few concepts. Although this worked well, we added more experiments to make sure our lab did all the experiments other, non A-T students used, plus the special ones we wanted. This proved almost disastrous as we overloaded the "open laboratory" with bodies.

Now we are even more strongly emphasizing techniques, using several major laboratory exercises to test all of the techniques. For example, the acid-base titration is an analysis of a 1.5M H_2SO_4 solution, including determination of (1) density (using analytical balance and pipet), (2) dilution (using pipet and volumetric flask), and (3) titration (using pipet and buret). Several calculations from the titration data are then required as a final laboratory exam for 1st semester. These include, for the original, unknown acid, calculation of N, M, m, % by weight, mole fraction, boiling point, freezing point, and osmotic pressure. You can readily see other experiments which could then be devised to verify several of these calculations. We are now pleased with the results the laboratory is getting.

In summary, we have some semi-quantitative data indicating students who go through the audio-tutorial program are at least as well prepared as the lecture-laboratory students. We are changing elements of the course, hoping it can evolve into an undeniably better learning environment. I believe our duty is to help students to diagnose their strnegths and weaknesses, to choose professions which use the strengths, and to help them cure the weaknesses <u>if they choose</u> to do so. We should also try to motivate and interest them to master the basic skills of chemistry, then get them to go beyond our requirements.

It is always a pleasure, at a Conference such as this, to see the number of people who are involved in similar pursuits. May it continue.

I would like to repeat a plea I have made before. This plea is for those who do go into the preparation of learning materials, let's all try to use a format which gives maximum exchangeability. This will allow us all to design our courses in many individual ways. It can even allow us to design a basic list of minicourses which all students must master, with options to allow each student to select a portion of the course to suit himself. That is a great motivational factor in itself.

Hopefully, with the many new teaching ideas available today, we will all provide better teaching/learning environments than ever before.

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Development of Learning Activity Packages

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Presented as a Workshop at the Fifty-Third, Two Year College Chemistry Conference, Delgado Community College, New Orleans, Louisiana, March 19, 1979.

PURPOSE

The purpose of this work session is to acquaint you with alternate ways of developing learning activity packages for use in your instruction. The development of a learning activity package will be carried out step by step to the final self-paced package. Application of each step to your present instructional method will be described.

PREREQUISITES

Before beginning this work session you should be able to:

1. Prepare behavioral objectives for units of your courses.
2. Discriminate among objectives which are meaningful, trivial, or too advanced.
3. Discriminate among test items which are appropriate, inappropriate, trivial, or too advanced.

OBJECTIVES

At the end of this work session you should be able to:

1. Prepare, with the aid of this worksheet, a flow chart of the series of steps to produce a self-paced unit of instruction.
2. Outline one short learning activity package for your students.

PRETEST

(In a complete learning package, a set of questions or activities would be included here to test each prerequisite and

each objective).

A. TASK ANALYSIS

Exercise 1. a. State the name of the best teacher you ever had. Try to identify what that person did to earn your high reward of "best teacher".

b. What were his or her:

Good Characteristics	Poor Characteristics
1.	1.
2.	2.
etc.	

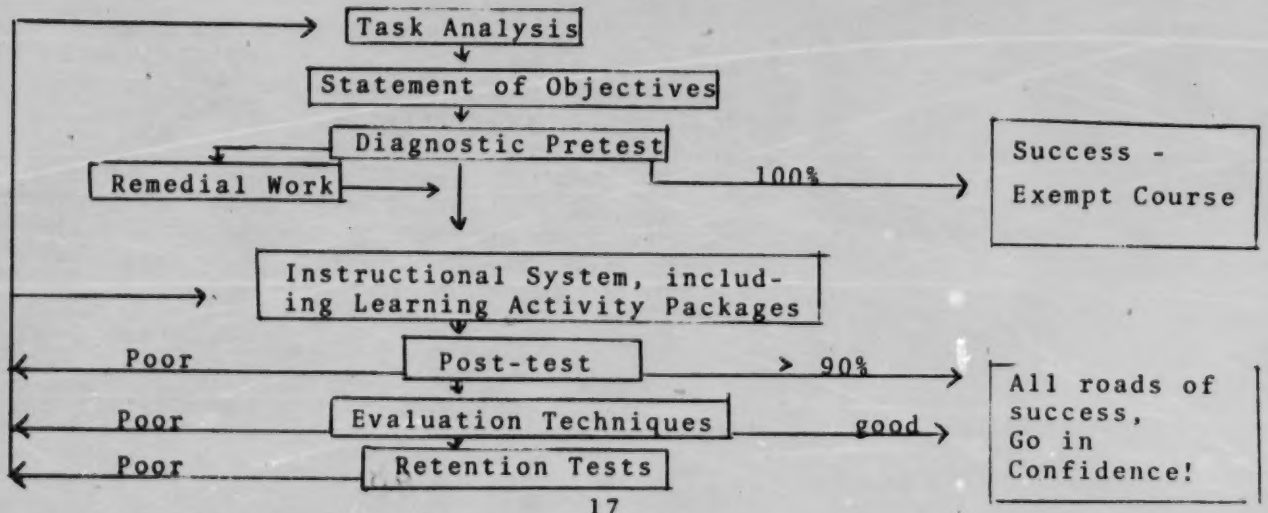
c. Repeat parts a and b for one "poor" teacher.

As a teacher of chemistry, you are aware of the problems associated with getting students to read a textbook or to master even a small amount of material. These problems become even greater when the student is undermotivated, ill prepared, put down by the system, or just plain dumb. We have all had days in which our teaching was exceedingly successful, others in which nothing seemed to work, and we weren't able to identify the causes.

I submit that we must begin to identify the cause and effect relationships of our teaching. I'll also bet your "best teacher" in Exercise 1 was someone who constantly kept you involved in the course, and was not necessarily the best lecturer or even the best chemist you knew.

Any endeavor in which scientists take part should be undertaken in a systematic way. Unfortunately, our teaching often must take second place to the many other demands on our time (research, committees, administration, large numbers of students, etc.), so we teach the most obvious way -- the way we, ourselves, were taught -- without taking time to evaluate what to teach and how best to do it.

One possible approach to the educational process is outlined in Figure 1.



This flow diagram allows us to identify weak spots all through our learning sequence, and helps to define our spheres of influence and responsibility. The quality of the incoming student and his background are not variables we control, only qualities we should identify as our "raw material" by using the pretest. The objectives we seek to achieve and require the student to meet should be determined independently. The task is how to develop that raw material into the finished product quickly and effectively. We can adjust all the other inputs, such as remedial work, grade scale, course structure, learning packages (text, workbooks, lab practice, etc.), until the students achieve greater accomplishment in less time. Only by requiring mastery of predetermined skills can we honestly and rationally counter the problems of grade inflation, accountability, and even malpractice in education.

Enough motivation and justification for the work you're about to do. Let us begin the real art of learning (and teaching), doing it yourself. Much of your task analysis has been done. You may have taught the course for years and have quizzed students over the most significant portions of the material. These quizzes are an important part of your learning package. Let's look at the steps involved and quickly outline a short learning activity package using your quizzes as the quickest route to a task analysis. Later you may want to redo the analysis if your intentions change.

A useful scheme for the task analysis is to make a list, such as:

TASK STUDENT MUST MASTER	IMPORTANCE

B. OBJECTIVES

Although this is a prerequisite and should not be covered at this time, let us review objectives.

Step 1. Choose your topic. Limit it to as small a package of information as you can, while still covering the topic fully. (Shoot for 1/2 to 2 hours of student study or activity time).

Step 2. Write your quiz over this topic. The quiz should include discussions, calculations, hands on experiments, or any other activities required to show competence with this topic.

Exercise 2. a. Do Step 2. Limit yourself for now to one quiz item you expect all of your students to perform at the 80-100% mastery level. State the item just as you would on a quiz.

b. What importance do you attach to this item? (Must all students do this 100% every time? 50% of the time?)

Step 3. Question your quiz.

a. Does it really cover what you want the student to know, do, or think about this topic?

b. Is this all you expect of him?

Step 4. Add any questions or activities to the quiz which you think should be there or remove any you think to be trivial.

Step 5. Restate each quiz question as a "behavior" (a behavioral objective"). A behavioral objective should do the following:

a. Tell what the student must do in such a way that everyone would agree on an appropriate test item.

b. Define the conditions under which the behavior is to be tested (e.g., "given the periodic chart")?

c. Specify the criterion of performance which is required..

Example: (Modified from a minicourse in General Chemistry).

At the end of this chapter, you should be able to: State the atomic number, the atomic weight, and the symbol of any element given the periodic chart and the name of the element. 80% of the answers must be correct.

Step 6. Check the verb in your objectives. Are the objectives measurable? They should be, since you wrote the objectives from quiz questions or laboratory procedures.

Check List

a. Is the verb one which clearly tells the student what he must do?

b. Did you tell him what materials he could use? (eg., Using the Periodic Chart. . .; Using logarithm tables . . .; etc.)

c. Should he know the performance which is acceptable? (e.g., "for all elements", "name 80% of the simple compounds given".)

Step 7. Place the objectives in the order which you believe will give the most efficient learning sequence. The most difficult objectives should be placed later in the list. Whenever possible, use a "terminal" objective which includes many, or all, of the previous objectives.

C. PREREQUISITES

Step 1. To meet your objectives, the student probably needs to know something or be able to perform a task assigned earlier.

Example: (From a minicourse on "Concentration of Solutions")

"Before beginning this minicourse you should be able to calculate the number of moles of a substance from the weight and the formula of that substance" (using the Periodic Chart).

Step 2. State your prerequisites in measurable terms. This enables the student to test himself to see whether he needs to review. To "know about moles" or to "read Chapter 6" is insufficient for many reasons, but primarily because you expect him "to calculate", not just to "know about".

Step 3. Add or remove prerequisites as needed as you write the subject matter.

D. PRETEST

Pretests are viewed at least four ways by different developers:

(1) to test prerequisites, allowing the student to determine whether review is necessary.

(2) to test the objectives to let the student determine whether he needs to study this minicourse at all.

(3) both of the above.

(4) both of the above, as well as to serve as a "post-test" for the student to test his preparation before taking your tests.

Exercise 3. a. Does the test item and objective you wrote in Ex. 2 require any prior knowledge? State it in performance terms.

b. Write a short test item (pretest) which would identify any student who could not meet that prerequisite.

E. BODY OF STUDY GUIDE

The "text" should be a series of information, tables, exercises, questions, figures, experiments, demonstrations, or whatever, arranged to make sure the student can pass your post-quiz and any others like it that either you or I would make up from those objectives.

Disgusted? This is "teaching to the quiz", which some view with disdain. I did too, just a few years ago.

Review your objectives --- is teaching to these disgusting? Isn't this what you decided the student should know or be able to do? Indeed wouldn't you be happy if all your students could meet this requirement? If there is more, state it. We could even state, "At the end of this minicourse, I would like you to enjoy and appreciate the problems of Chemical Research, but I don't know how to determine whether or not you really do." Students would appreciate such honesty!

Step 1. Give a brief introduction of information for the student to study.

Step 2. Have him do something. This can involve several things:

a. A "programmed" question which asks him to use the information in Step 1. He should be able to get this question correct for encouragement!

b. Pick up an object and describe it. A "no-fail" opener is interesting. He can see or feel something, and you can lead him into other observations. Audio taped discussions work well here. For example: pick up your pen or pencil and list all the physical properties you can in 3 minutes.

c. Describe a chart, table, or demonstration.

d. A "thought" question which hopefully causes him to review his experiences outside and/or inside school or lab, then relate it to the topic under study.

This can be a gamble. He can be turned off when he fails to come up with what you ask. Thus some writers will not use this technique.

However, he is greatly rewarded when he does come up with the self-discovery of a concept, with the question as a prod. From my experience, it is more than worth the gamble, but some students do feel it detracts from their confidence. This loss of confidence is lessened, perhaps eliminated, when the student is told beforehand to "guess" or "speculate on" the topic. Using audio tapes, he can be told beforehand that he isn't expected to be correct, but just to try!

I believe strongly in this type question.

Exercise 4. Choose and write out instructions for one "do it" exercise to introduce students to the concepts on techniques needed to master your objective from Exercise 2.

Step 3. Answer the exercises clearly in the text or in a special answer section. Progress through the learning package in steps small enough that your students aren't lost, but large enough not to be trivial. Most importantly, make sure any student who tries can reach the terminal behavior. (This is the place to use all the ingenuity you have to reach that student, to teach!)

Step 4. Keep him busy doing things, not just reading or listening. (An audio-tutorial workshop at Purdue once decided no more than 3 minutes or passive reading or listening at one time should be allowed. Hasn't this handout/talk proved the validity of this statement?

Exercise 5. Take a few minutes to outline the steps you would have the student go through to practice and master Objective 2. Integrate thought, pen and paper, hands-on, and other exercises as much as possible.

Step 5. Check your progression of text and activities for:

a. Gaps in the instructional sequence. For example, can he really go from a description of a calculation to doing it all in one step? Can it first be broken down into several steps, leading him to the correct thinking processes? Then give other problems in which he ties all the steps together into the type problem you expect him to solve.

b. Did you begin too high? Assuming too much of the background can defeat him early. A brief review of topics already covered is well worth the effort. Ditto, a review of prerequisite material.

c. Are there visual aids, tangible objects, experiments, etc., which you should use to clarify or reinforce the learning? Add these if they either save time or provide better performance.

d. Long-windedness. Can something be eliminated without hurting the sequence? Then remove it. If it is there for stimulation, can it be better handled in some other way? Lecture, general assembly, or personal contacts may be better for stimulation than splitting up the learning sequence. Some developers prefer the "lean" approach. Present as little information as possible, give it to the student, then test him. If he can then do it, you've succeeded!

e. Did you answer those questions the students

always ask? There are always a few questions we hear every semester. Be sure you address these clearly.

f. Is the package too long? If he can master all of it in "one sitting" of 1/2 to 2 hours, it will be okay. If 3 hours or longer, can it be revised. (Note: This is up to 2 hours at his pace, not at yours.)

Step 6. Review the objectives and prerequisites. Better yet, have an associate review these with you. Are they sufficient for the minicourse you've developed? Are they clear? Are there too many objectives? Did your minicourse cover them all? If not, delete them or add sections to the minicourse. Were those prerequisites all really needed? If not, drop them.

Exercise 6. If your time permits, ask the person next to you to look over your outline and share ideas about it.

Step 7. Be brave, test your first draft on some of your students. Grade the quizzes carefully to find out what wasn't learned. At this point you get your first rewards, even for poorly designed minicourses. However, be ready for real criticism, mostly constructive.

Step 8. Revise to teach what wasn't learned last time.

Step 9. Test revised material on students. Now you may find a new set of errors common to the quiz performances, because the first problems were cured, others were found.

Step 10. Revise and reuse. Each time the students will do better unless you revise in more confusion. Most of us do that at least once. What then? Just revise again.

After the first draft, revise only toward a particular end, to cure a particular problem.

F. EVALUATION: THE POST TEST

Some purposes for evaluation may be:

1. Ranking students. This may be the most common use of evaluation.
2. Evaluate student knowledge. This can help us redesign our learning packages, help the student identify weaknesses so he can improve, and help the student gain in confidence.
3. Evaluate teaching methods. This can identify problems in the learning sequence which makes learning inefficient or ineffective. Once identified, these can usually be corrected.

4. Attitudes. Does the behavior of the student change, both as he desires and as you desire? This is sometimes difficult to test, and should not be confused with the learning of skills or information.

To improve our evaluations, as well as our teaching, we should carefully consider:

1. Type of evaluation. A written quiz can't determine whether a student can repair an instrument, but can tell whether he knows the steps involved in that repair. Ask: Which does he need at this time?

2. Obtaining comparative results. Does the student learn anything? The only way to know is to test his knowledge or techniques both before and after he uses our learning packages.

To be a useful evaluation tool, the post tests must be appropriate and in "performance agreement" with the objectives chosen earlier.

Step 1. Choose test questions which thoroughly represent the objectives for this minicourse. A test item can include any activity you want, including laboratory skills.

Step 2. Check the objectives. Are any of these "terminal" in that they use several of the other objectives? If so, you may want to let one question test several objectives.

Step 3. You may need to have two or more questions over one objective if that is more important than some of the others. Did you make clear that importance in the objectives?

Step 4. Check to see that the test is clear, even for the poorly prepared student.

Step 5. Eliminate any questions not specifically covered on the objectives. (Al alternative: Add another objective if this question is important.)

Step 6. Review the minicourse. A student who works his way through this material should be able to pass this post-test at a high (80-100%) level of mastery. Can he? If not, revise either: (a) objectives, (b) instructional sequence, (c) post-test (d) all three.

How can you check to find if your evaluations are appropriate? The following exercises may be of some help.

For a test item to be acceptable it must:

1. Require the performance stated in an objective.
2. Give the student the information promised in the objective.
3. Place the student within the setting and time constraints stated in the objectives.

Exercise 7. Match the following objectives to the appropriate test items: (This is a prerequisite, but let's review it anyway).

Objective 1. Perform triplicate analyses for residual chlorine when given the appropriate equipment and solutions. The analyses should require no more than 30 minutes and all three should be within ± 10% of the mean.

Objective 2. From memory, describe the steps involved in performing the analysis for residual chlorine and list the most common errors made in the analysis.

Objective 3. Observe an analysis for residual chlorine being performed and state which steps are done incorrectly and suggest remedies for the incorrect procedure.

Test 1. Watch a student do the residual chlorine analysis and give a critique of this technique.

Test 2. Perform an analysis for residual chlorine.

Test 3. Describe how to perform an analysis for residual chlorine. Included in the description should be a list of the most common errors made during the analysis.

Exercise 8. To what student or trainee group would each of the objectives in Exercise 1 apply?

Exercise 9. Evaluate the following objective and test item for appropriateness:

Objective: When given a table of observations, construct a graph which meets the stated criteria for an acceptable graph.

Test Item: Using the following table of bacterial count for a given chlorine dosage, estimate the bacterial count if the chloring dosage were 12 milligrams per liter.

Chlorine dose (mg/l)	5	6	7	8	9	10
Bacterial count/ml	$6x10^6$	$1x10^6$	$7x10^5$	$9x10^4$	$1.5x10^4$	$5x10^2$

Exercise 10. Check the appropriateness of the following objective and test item:

Objective: From memory, state the number of electrons in the outer shell of an atom of any given element when given the name or symbol of the element.

Test Item: Using the periodic chart, how many total electrons should be found in an atom of magnesium (Mg)?

Exercise 11. Was the objective in Exercise 4 fair? Unreasonable? Trivial? Explain your answer.

Exercise 12. Use any two objectives you have written in earlier worksnops and prepare one appropriate test item and one inappropriate test item. Make the inappropriate test item sound as nearly acceptable as possible.

G. ALTERNATIVE MODES OF DELIVERY

Step 1. Choose existing learning materials (text, minicourses, etc.) as the basic learning package. This may be your present text.

Step 2. Write objectives, prerequisites and test items for this text.

Step 3. Identify weak spots for your students.

Step 4. Prepare learning activity packages as supplements for the basic package. Later you may want to replace the basic package with your own materials, but allow time for development.

Step 5. Choose the delivery mode to best accomplish your task.

a. Lecture system plus objectives.

b. Lecture system plus objectives and prerequisites.

c. Lecture system plus objectives, prerequisites, and evaluation techniques.

d. Self-instructional system with lecture system plus objectives, prerequisites, evaluation techniques, and commercially available materials.

e. Self-instructional system with lecture system plus objectives, prerequisites, evaluation techniques, commercially available materials, and specially prepared self-instructional materials for your students.

f. Self-instructional system with lecture system plus objectives, prerequisites, evaluation techniques, commercially available materials, specially prepared self-instructional materials for your students, with audio-visual and/or computer aids.

H. SUMMARY

If we decide something is important for the student to know or do, and for us to teach, then let us require mastery of the subject. This ends the "accumulation of ignorance" which we often must contend with. To require mastery, might require that we allow retests in order to use the test as a true evaluation tool.

Also, we must build feedback loops into our course structure. If we learn from our tests that students aren't learning, we must revise the learning materials, our evaluations, and/or our motivational techniques. This is the true value of evaluation in education and training, just as it is in our research.

If you can successfully accomplish these things, you will be the expert in your particular area, for you will know more about what gives students problems, what teaches them efficiently, and what to really expect from your students than any one around. Your students will be a tired, happy, perhaps even enthusiastic bunch. Your fellow faculty may look at you askance and question your standards because your grades go up. However, you will clearly know what your standards really are!

One last appeal: Don't drop your standards without strong and overriding cause. Change your approach. Begin where the student is. This may mean lowering your entry standards or prerequisites, for now you will know the real level of competence of the incoming students.

Shoot as high as ever, or higher. Expect good, strong, performance and you'll get it. You'll also get many complaints about overwork. But growth and satisfaction can only be gained by working hard at a difficult task, and achieving that task. If the student finds that you're expecting only 8th grade math, and physical science, his self-image is not improved, no matter what his grade.

I also have non-measurable objectives in my plans, but I do not require these of the student. Yet, I do try to achieve some of these as well as the stated ones.

The real reward for faculty and student comes when he states in nonbehavioral terms: "I never thought I could learn Chemistry, but I am learning it. My roommate and his classmates come to me when they have difficulty!" That is reward! I invite you to harvest it.

I. SOURCES FOR MORE INFORMATION: This list is a sample of groups available outside the Chemists normal contacts. It is by no means exhaustive.

NSPI Journal
National Society for Performance and Instruction
Box 266, Route 1
Charles Town, W.Va. 25414

Education Technology
140 Sylvan Avenue
Englewood Cliffs, N. 07632

International Congress for Individualized Instruction
c/o Dr. David Husband
Department of Biology
University of South Carolina
Columbia, SC

The Center for Personalized Information
Georgetown University
Washington, DC

Robert Mager's Series of books from Fearon Publishers
6 Davis Drive
Belmont, CA 94002

Journal of College Science Teaching
The National Science Teachers Association
1742 Connecticut Ave, NW
Washington, DC 20009

Examples were taken from: book, Allen, Joe F., "General Chemistry Minicourses", Burgess Publishing Co., 7108 Ohms Lane Minneapolis, MN 55435

Self-Paced, PSI Organic Chemistry in the Community College Situation

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Presented as a part of a symposium on Personalized Systems of Instruction at the Fifty-Third Two Year College Chemistry Conference, Delgado Community College, New Orleans, Louisiana, March 19, 1977.

Introduction

The organic chemistry at Prince George's Community College is a two-semester course. The first semester is a 4-credit hour course. The second semester is divided into a 3-credit lecture course and a 2-credit hour laboratory course.

This presentation focuses on the first semester organic chemistry as taught at PGC College. As stated before, this is a 4-credit hour course. The average enrollment per semester is 60. The requirement is one semester of general chemistry or Chemistry 101. The course consists of two major parts the lecture and the laboratory. The laboratory is taught in a traditional manner at the present time and will become semi-self-paced next year. The lecture part is completely self-paced. The textbook is recommended, not required. The one presently used is Morrison & Boyd, Organic Chemistry. However, any of the standard organic chemistry textbooks such as Ternay, Solomons, Ahlinger, Streitwieser, etc., can be used. There are no regularly scheduled lectures. The number of lectures per semester is 3-5. They are used for reviews, for discussions of the more difficult topics such as stereochemistry, certain mechanisms, etc. (more difficult topic is defined by the students); or for enrichment purposes with invited guest lecturers.

The questions that immediately imposes itself is: "Why the change from the traditional to the self-paced teaching mode in a course which is considerably more conservative than the general chemistry?" There is only one answer to this: "quest for improvement".

For several years organic chemistry at PGC College was taught in a traditional manner with three hours of lecture per week and 4 one-hour exams and a final exam.(Figure 1.) In order to decrease the attrition rate in the course and help the students master the subject matter, additional four exams, which served as retests, were given. An abundance of handouts used to supplement the subject matter was given every semester. And yet, the same problem persisted. Because of the heterogeneous nature of the student body, the lecture method served well only the students in the middle. A considerable dissatisfaction was felt by the better and the slower students. One

felt they could master the subject matter faster, if permitted, and the others felt the course was too fast and too demanding. I faced the same eternal doubt that every real teacher faces - what is the best way to teach my class, to reach almost every student in the class? It appeared to me that the self-paced teaching was the answer. That using this teaching mode, both the better and the slower students would be satisfied because they could achieve the mastery of the subject matter and reach the cognitive level required at their own pace. It was expected that the performance level would increase, that the attrition rate would decrease, and that the feeling of dissatisfaction would completely disappear. The self-paced teaching of organic chemistry was thus conceived and instituted in the Fall of 1975.

THE ETERNAL DOUBTS

Confused Clyde

HISTORY OF THIS SELF-PACED COURSE

What was the format of this course before ?

A typical lecture course with four hourly exams and a comprehensive final exam.

Why the change ?

–To lecrease the atrition rate of the course.

–To reach every student of the heterogeneous student body.

–To formalize the handouts given in the course and eliminate the formi tests, retests, etc.

When was this self–paced course initiated ?

In the fall of 1975

Figure 1

The Course Organization

The topics covered in depth are: hydrocarbons, aliphatic and aromatic with an emphasis on stereochemistry, reaction mechanisms, and synthesis. Alcohols and alkyl halides are discussed without going into details. The material covered in the course is analogous to the first twelve chapters of Morrison & Boyd - Organic Chemistry. The material presented in these twelve chapters is divided into seventeen units or Self Instructional Packages - SIP's. The number seventeen resulted from the attempt to keep the size of the units and their level of difficulty uniform. The student is informed about this self-paced course through the college catalogue, the class schedule and inevitably through the "grapevine". The details of the course, such as the learning process, testing, grading, etc., are presented in great detail in an extensive course syllabus given to the students on the first day of classes.* The course syllabus contains, also, suggested calendar with the regular exam passing dates and a calendar for the accelerated schedule. In the first session the instructor explains all the details of the course and provides the students with all the necessary information. This informative session will be available on the videotape for the Fall Semester of 1977.

How does a student acquire the mastery of the subject?

In a traditional course there are two resources available to the student (a) the textbook and (b) the lecture notes which are inconsistent and often unrealiable (who is to be blamed - the student and/or the instructor?) In the self-paced organic chemistry course, as taught at P.G.C.C., the student has several means of mastering the subject matter (a) the textbook (b) the SIP's, (c) the tapes which accompany the SIP's, and (d) the staff.

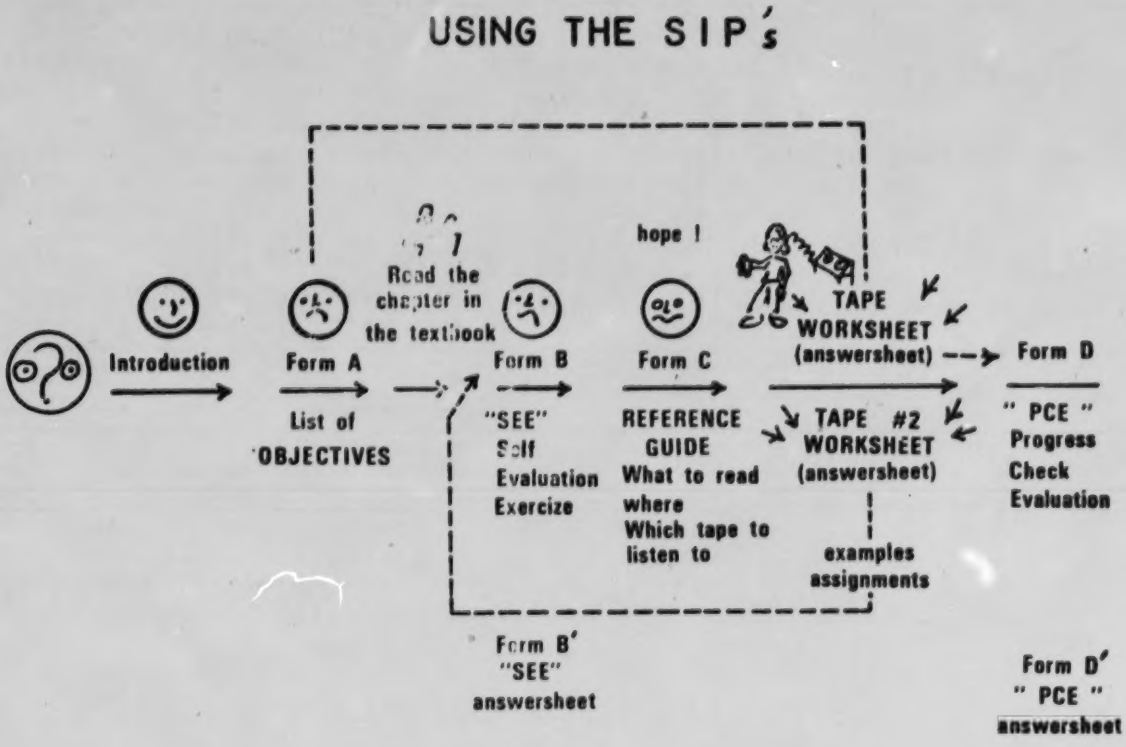
The staff in this course consists of: the instructor, the permanent proctors, and the temporary proctors in lieu with the PSI philosophy.

The permanent proctors are students who have successfully completed this course before. They are "permanent" help during the entire semester. They can be paid for their work if the funds are available or be given an education credit for the experience, if such education credits are in existence.

The temporary proctors are either peer proctors or second semester students. Peer proctors are students who are ahead of their peers in the same course and agree to tutor or proctor. The incentive is few points, a negligible number in the total number of points. The benefits to this student proctor are two-fold. The constant review of the topics leads to a much better comprehension and the social aspect of it - it is a position of prestige. The other temporary proctors come from the second semester of organic chemistry. Their reasons for tutoring and the benefits are the same as for the peer tutors.

The SIP

Each SIP has the same format. (Figure 2) It consists of several parts. An introduction, limited to few paragraphs of humorous or informative nature and meant to enlighten the subject matter discussed, is included in almost every SIP.



Form A or list of objectives unequivocally shows the student what he is expected to master in that SIP. The objectives state specifically the definitions, reaction mechanisms, synthesis, to be mastered.

Form B is a Self-Evaluation Exercise - SEE or a pretest. It contains 10-30 multiple choice questions testing every aspect of the topics covered in the respective SIP. Form B^1 is an answer key to Form.

Form C is a reference guide which gives the reference for all questions in Form B with the textbook and the tapes. Presently, the only textbook used in the reference guide is Organic Chemistry by Morrison & Boyd. However, this will be expanded to include the other standard organic chemistry textbooks.

Each SIP is accompanied by one, two, or three tapes which provide the student with clear explanations of specific reactions and reaction mechanisms. Each tape is accompanied by a worksheet - the most important part of each SIP. The worksheet contains the examples which are discussed in the tape immediately followed by assignments, simple in the beginning and more challenging at the end of the tape. These assignments are not multiple choice questions. They are more or less intriguing questions leading to a complete mastery of the subject matter discussed. The tapes are approximately 20 minutes long. However, when used properly with the worksheet, textbook and answer sheet, each tape requires approximately two hours to be completed.

Form D is a Progress Check Evaluation - PCE or a posttest. It is very similar to Form B and contains also 10-30 multiple choice questions. Form D' - an answer key to Form D is also included.

How does the student use the SIP? He reads the introduction and the list of objectives. Now, knowing what to study, he studies the material in the textbook. To test his knowledge, he completes Form B (SEE) to see for himself what he has not mastered thus far. The reference guide C will guide him to the proper resources, namely, the right sections of the textbook or the appropriate tape. He listens to each tape and, more importantly, completes all the assignment on the worksheets. The worksheets are the highlights of each SIP. The completion of the assignments on these worksheets is a must, and a requirement for success. To prove to himself that he has truly mastered the topics, the student completes Form D or the posttest. He is now ready to take the test.

The other way to achieve the mastery of the subject matter, and one that is used routinely by many students, is to go straight to the tapes, worksheets and answer sheets from the objectives, effectively skipping Forms B and C. Often, the textbook becomes the supplementary material and the SIP's with the tapes are used as the primary resource.

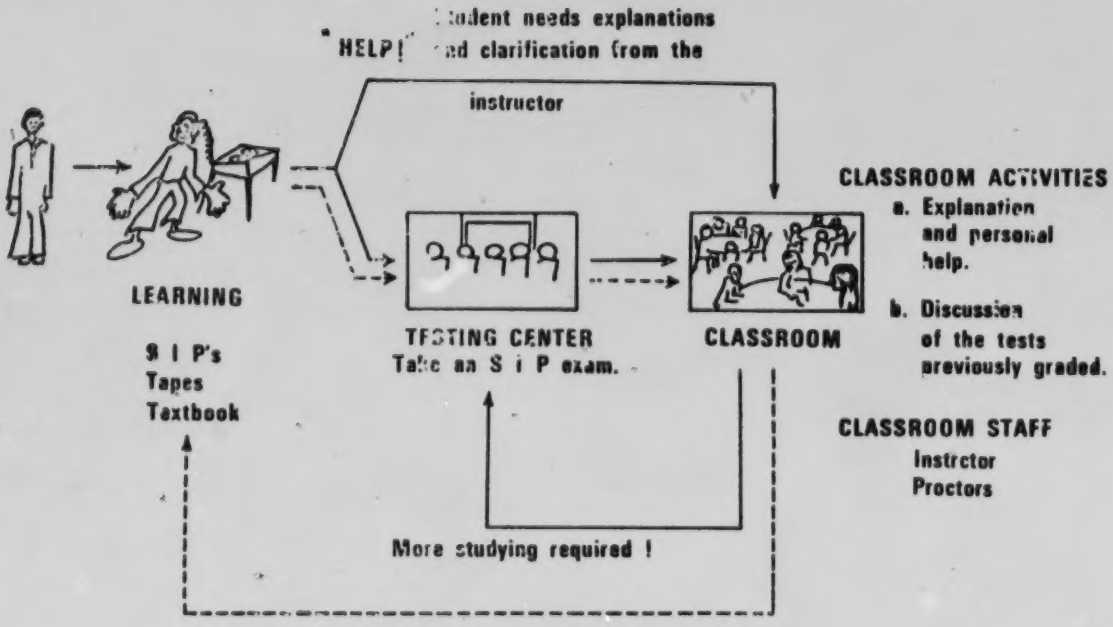
The Learning Process Figure 3

How does the student achieve the mastery of the subject in this course? As stated before, he has several resources, namely the textbook, the SIP's, the tapes, and the staff. The student learns on his own. The responsibility for learning the material rests with him. When he feels ready for the test, the student goes to the Testing Center to take the test. The Testing Center at PGCC is open seventy-four hours a week. However, if there is no such convenience as the testing center, the testing can be carried out in a classroom at designated times. These SIP tests contain no multiple choice questions, but challenging "road-map" problems, synthesis questions, mechanisms, etc.

How does a student find out if he passed or did not pass the test? By checking at the testing center the next day, (for students have a card that is kept there, or by coming to the classroom at the regularly scheduled time. The staff is present in

the classroom twice a week for the duration of two hours. In the classroom, the tests are being discussed, the mistakes, if any, are pointed out and the student is advised to retake the test. He may be given extra problems to work with, or he is congratulated and encouraged to go on to the next SIP. The atmosphere in the classroom (which is not a lecture hall, but a room with tables and chairs, is informal and relaxed and a subtle effort on the part of the instructor and the proctors is made to stimulate the students to hurry on and decrease the procrastination - a usual vice of a self-paced course. The other possibility is, that during the studying, the student finds certain facets of the subject incomprehensible and comes to the classroom to seek help from the instructor and/or the proctors. Every attempt is made to clarify, explain and help with the problems. From the classroom, the student goes to the testing center, if he feels ready to take the SIP exam now, or goes back to do some more studying.

LEARNING PROCESS



The Grading System

The grade is based on the percentage of the total number of points accumulated in the course. There are three basic parts of the final grade: the final exam, the laboratory part and the SIP exams.

The final exam is a comprehensive exam which covers all major aspects of the course. It constitutes approximately 1/3 of the final grade. There is an optional early Final Exam given three weeks earlier than the normally scheduled one. This is available for all the students who are pursuing the "accelerated schedule" and have completed fifteen SIP's by that time.

The laboratory part is also approximately 1/3 of the final grade or total number of points. It is based on the weekly quizzes, laboratory reports and the final lab exam which has two parts - practical and written part.

The seventeen SIP exams constitute somewhat less than 1/3 of the total number of points. There is no deviation in the number of points given for each SIP exam. The student either passes or does not pass the exam. The minimum requirement for taking the final exam is successful completion of fifteen SIP's.

RESULTS

The statistical evaluation of the results over a period of seven years show the following:

There is no significan improvement of the attrition rate. This is not a true reflection of the existing situation, however. I- Incomplete is not given at PGCC except in special cases. There is no special grade such as TP - Toward Passing for students who have not quite finished the self-paced sequence. Consequently, the student has to withdraw even though he needs perhaps only two more weeks to complete the course.

The performance level is increased with higher percentage of A and B grades as compared to the traditionally taught course. (This should not be confused with the inflation of grades.)

These are the evident, tangible results and the ones of an interest to a statistician. However, there are other aspects to be considered. Although intangible, these results are very important to the instructor. There have been numerous comments given both verbally and in writing to the effect that the student "learned how to learn", that he "felt at ease reading a science book or an article for the first time in his life", that Chemistry is not such an imposing, unreachable subject after all", etc. The level of the intellectual maturity of many students evidently increased. And, finally, there is a tremendous satisfaction for the instructor who evidenced this progress in these one-to-one situations during the semester.

Self-Paced, Individualized Laboratory Instruction in General Chemistry

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Presented as a part of a Symposium on Innovation in Communicating Chemistry at the Fifty-Fourth Two Year College Chemistry Conference, Brandywine College, Wilmington, Delaware, April 23, 1977.

Classical volumetric and gravimetric analyses, instrumental analysis, and some qualitative analysis are included in a sophomore level two-credit lecture laboratory course. One hour of lecture and a three hour laboratory are assigned each week. The course has as prerequisites one semester of general chemistry and concurrent enrollment in, or prior completion of, an additional three-credit general chemistry lecture class.

This course, entitled Chemistry 103, was initiated at Prince George's Community College in the spring of 1974 so as to bring our chemistry program in line with that of the neighboring University of Maryland, College Park, to which many of our students transfer. The development of the course has continued since. In the fall of 1975, the course was self-paced and individualized. Lecture Notes and tapes on laboratory procedures were developed to supplement and enrich the discussions in the laboratory manual, Laboratory Chemistry, Volume II, PGCC, 1975. Formal lectures were reduced to about four times a semester. When no formal lecture was given, the one hour of lecture time each week was devoted to helping students with laboratory writeups, clarifying problems with topics in the Lecture Notes, and/or handling questions from the pretests which are given for each block of three or four experiments.

My previous experience had taught me that experiments done in groups, particularly experiments with sophisticated laboratory instrumentation, were meaningful for perhaps one member of the group. The rest of the group merely followed along taking down the appropriate data from the "group leader."

To alleviate this problem, I started staggering the experiments over the semester so as to give each student the opportunity to use the available instrumentation on an individual basis. As a consequence, there are frequently three or four different experiments going on simultaneously during a given laboratory period. With several experiments scheduled each week, it was virtually impossible to coordinate a formal lecture schedule with the lab sequence. To overcome this problem, the Lecture Notes were developed. Students can then be assigned that portion of the Lecture Notes which pertains to their particular experiment for the week.

Course Procedure

The laboratory program is separated into four different

Blocks. For each experiment within a given Block, there is a reading assignment in the Lecture Notes. This provides theoretical background for the particular experiment. The lab procedure is from our own laboratory manual, Laboratory Chemistry, Volume II, PGCC, 1975. Tapes of laboratory procedural hints, etc., are available in the laboratory. These are brief -- 5-9 minutes long. So a student prior to performing any laboratory work should have fully prepared himself for the experiment. As a consequence of this background preparation, many students were able to complete the experimental work more rapidly than anticipated. To accommodate these students who are more highly motivated and better prepared, the course was self-paced -- in one direction! After completing Block I, students can move ahead in the lab program provided the instrumentation is available and not being used by some regularly scheduled student. A summary of the course procedure is shown in the following Table I.

Table I

General Procedure for Chemistry 103

Step 1.	Read the Lecture Notes relative to your experiment.
Step 2.	Read the Laboratory procedure for your experiment prior to coming to the laboratory to listen to the tape or to do lab work.
Step 3.	Listen to the tape on your experiment. Keep your laboratory manual available while listening to the tape so that you can make notations as you go along.
Step 4.	Perform the experiment during your scheduled laboratory time.
Step 5.	Go over the Unit objectives for the laboratory experiment just completed.
Step 6.	Attempt any problems on the Pretest relative to the experiment just completed.

Course Topics

As mentioned previously, the laboratory program blends a little of the old with a little of the new. We start with classical analytical procedures and then go into some instrumental methods of analysis, and finally end up with three weeks of qualitative analysis. The amount of instrumental work has been increased over the past two years as a consequence of recent purchases of a 60 mHz Varian NMR spectrophotometer and a Varian EM 600 mass spectrometer. During the semester, the students use single and double beam spectrophotometers for visible analysis, pH meters, polarimeters, electrodeposition equipment, refractometers, in addition to the NMR, IR and the mass spectrometer. Using these latter instruments effectively has been somewhat of a challenge to me.

Some students in Chemistry 103 have already completed two semesters of organic chemistry; others have had only the one semester of general chemistry. To handle these divergent background, I use one of the lecture periods to survey organic chemistry with an emphasis on functional groups. An excellent film on NMR is also available to the students. Likewise, the lecture text which we are currently using in our general chemistry course, General College Chemistry, by Keenan, Wood and Kleinfelter, published by Harper and Row, exposes students to organic chemistry early in the text and continues to use organic compounds to illustrate theoretical concepts.

This past semester we have developed two video tapes; one on the NMR and one on the mass spectrometer. These video tapes, approximately 15-20 minutes in length, go into the operational procedures for these two instruments. A TV is available in the laboratory when these instruments are being used. All students are required to view the video tape prior to using either of the two instruments. We feel that these video tapes have been most helpful. They teach the student, they help prevent costly damage to instruments due to misuse, and they free the instructor to be available to all the students in the course.

A list of the topics covered in the Lecture Notes is shown in Table II.

Table II

Topics Covered in Lecture Notes

1. Evaluation of Experimental Measurements
2. Gravimetric Methods of Analysis
3. Volumetric Methods of Analysis
4. Spectroscopic Methods
5. Potentiometric Titrations
6. Polarimetry
7. Electrodeposition and Coulometry

You will note that no qualitative analysis is shown, yet we use three weeks of our laboratory program for analysis of several of the groups. The students are referred to College Chemistry, by Nebergall, Schmidt and Holtzclaw, published by D.C. Heath, which is on reserve in our Learning Resources Center. In addition, I use one of the formal lectures for a discussion of qualitative analysis. Handouts are also given to each student.

The specific experiments for the semester are shown in Table III.

Table III

Laboratory Experiments

1. Volumetric Determination of Iron
2. Gravimetric Determination of $BaSO_4$
3. Equilibrium Constant for $FeSCN^{+2}$ using Spectroscopy
4. Kinetics of Sucrose Inversion using Polarimetry
5. Potentiometric Titration of a Weak Acid
6. Determination of ASA in Aspirin using Spectroscopy
7. Electrodeposition of Copper
8. Instrumental Analysis of an Organic Unknown
9. Chloride Analysis - Volumetric and Gravimetric
10. Qualitative Analysis

Grading Policy

The grading policy is shown in Table IV.

Table IV

Grading Policy

Laboratory Notebook	200 points
Block Exams (4)	200 points
Laboratory Technique	50 points
Final Exam	150 points
Total	600 points

For each Block, a pretest with solutions is given. All students take the Block Exam on scheduled dates. Students have the option of taking a retest on each Block. The higher of the two grades goes into their grade point computation.

A large portion of the grade is assigned to the laboratory notebook. We stress the importance of careful data taking in the laboratory and clear writeups in a laboratory notebook. Part of the grade reflects the students; accuracy in the laboratory unknowns and part reflects how well the experiment was written up.

Course Evaluation

The course is taught to about 35 students per semester. Retention rates have not changed appreciably as a consequence of

the self-pacing. The grade distribution pattern is higher for those students completing the course, when compared with other courses which I teach. I would attribute this to the retest policy for this course.

As presently taught, the course required a sizeable amount of prep work for the laboratory staff. Likewise, trouble shooting of instrument malfunction is a problem particularly when there is inadequate laboratory staff.

Despite these difficulties, I feel that the course is working well and is providing a valuable educational experience for the students at P.G.C.C.

CURRENT CONCERNS IN CHEMICAL EDUCATION

Lab Safety is Not a Game of Chance

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Presented as a part of a Symposium on Current Concerns in Chemical Education at the Fifty-Second, Two Year College Chemistry Conference, Penn Valley Community College, Kansas City, Missouri, October 30, 1976.

About 60 years ago, the Industrial Community of the United States established a committee to try to prevent accidents from occurring. This committee's concern was enacted - finally - through the Workmen's Compensation Act of 1912. Employers were now required by law, to pay for job related injuries. As the need for organized safety grew, the National Safety Council was established. This council, through the years has produced much information about safety, and safety related matters. Many of their findings and suggestions have been adopted by industry.

Health care and educational segments did little to examine their safety responsibilities until 1954. Even then, little was done, and much left to chance - except for fire safety - and only then, perhaps due to a rash of hospital, school, and nursing care fires. Through constant efforts of many, finally a bill was introduced into the Congress known as the 'Williams-Steiger Occu--pational Safety and Health Act'. In September of 1970, the President of the United States signed this act into law. This act became e-fective on April 28, 1971. This law is administered by by the Secretary of Labor.

I shall cover highlights and mention a few important legal requirements of the law.

COVERAGE: Occupational Safety and Health Act of 1970 (OSHA) Safe Employment and Safe Place of Employment.

> "Each employer shall furnish to each of his employees, employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees. (Section 5 (a) (1)

It is the ruling of the Department of Labor, that practically all employers in the country are covered by the act. Private schools, university and college employees are covered, but students, unless employed on a full or part time basis, are not. Graduate students with paid teaching assignments are covered. Students under Grants-in-Aid and scholarship are covered only if they have employee status. State and local government colleges and universities will not be covered until State plans are in effect. Employees of local school districts are not specifically covered by the act. But before a State's gaining approval of its State Plan under the Compliance program, the State has to assure the Secretary of Labor and the Ass't. Secretary that the same rules, regulations, and procedures that apply in private industry will apply in its State employees, including local school employees. At such time as the State comes into the State-Federal system, these employees will be covered basically by the same regulations. At present approximately 33 states have submitted to the Secretary of Labor plans for development of State OSHA. This is to be done in 3 phases:

1. Submission of plan to Secretary of Labor.
2. State is allowed 3 years to develop plan.
3. Upon inspection by OSHA, any discrepancies or failures that are found, the State is given one year to correct.

COMPLIANCE WITH STANDARDS: Each employer shall comply with occupational safety and health standards promulgated under this act. (Sect. 5 (a) (2)

Perhaps most important -- The Training Requirements -- I quote from Forward Training Requirements of OSHA Standards:

> The employer should be able to show the OSHA Compliance Officer that training has been given to the employee, based on an analysis of the tasks performed by the employee. As a minimum, such tasks analysis should identify the actual and potential hazards the employee would encounter on the job, and the equipment and practices the employee should use to minimize the risk of injuring himself or another employee.
>
> (Training Requirements of the Occupational Safety and Health Standards; Foreword)

RECORDKEEPING

As with most government works, employers are required to maintain accurate records of work-related deaths, injuries and illnesses, which involve medical treatment, loss of consciousness, restriction of work or motion or transfer to another job. (Section 8 (c)(2)

ADMINISTRATION

Administration and enforcement of the Act are vested primarily in the Secretary of Labor and in a new agency - The Occupational Safety and Health Review Commission which is made up of 3 members appointed by the President of the United States. Research and related functions are vested in HEW and carried out by the National Institute of Occupational Safety and Health - NISHA. Occupational safety and health inspections will be made by inspectors located in offices in regions of the United States. There are 10 regional offices.

In general, job safety and health standards consist of rules of avoidance of hazards which have been proven by research and experience, to be harmful i.e. fire protection standards. I have a huge Book of Standards that covers everything from soup to nuts. One typical standard -- aisles and passageways shall be kept clear and in good repair, with no obstruction across or in aisles that could create a hazard. Another example, "In an operation such as chipping, drilling, riveting, grinding, and pouring babbit metal, in which the eye hazard of flying particles, molten metal, or liquid chemical exists, employees shall be protected by suitable face shields or goggles.

A few other legal requirements under the Act:

1. Complaints of violations
2. Enforcement
3. (Important) Protection against harrassment.

While all industry under the law is to insure, so far as possible, safe working conditions, the potential in a Chemistry Lab offers hazards often beyond the specific standards. It may fall on the faculty itself, in the absence of a safety officer, for developing procedures for making the lab as safe as possible. Personnel in a lab are exposed to many potential hazards - broken glass, chemicals, some of which may alone be harmless, but in combination can be flammable, explosive or toxic. There is an abundance of equipment of all shapes, kinds and sizes which make a chamical lab a great target for accidents.

A Maryland Safety and Health Officer tells of a Clinical lab that had a strange history of mental disturbances of personnel over many years. When the building was wrecked, seven pounds of mercury was found. Mercury which does break in globules and can land in small cracks can cause personality changes and mental disorders among people exposed to it.

Lab safety on campus cannot be left to chance. A large

number of students, actually inexperienced, use the labs and usually each lab is operated independently of the other, no one is responsible for the overall safety. Perhaps the first step in a lab is to see that one individual is appointed as OSHA safety officer.

When North Carolina state OSHA Safety Officer Plan was approved and the University became subject to OSHA standards, Dr. Frazier, former Director of Occupational Health Research Project for the rubber industry, presently professor of Industrial Health in the School of Public Health's Environmental Sciences and Engineering Department at the Univ. of North Carolina was called on to help implement OSHA. Dr. Frazier states: "We saw bottles of acetone used as door stops, in some cases where radio-active materials were used the ventilation systems in the lab hoods were blowing air out into the room instead of pulling it in." In his words, in general, we found that lab supervision of safety was nil.

Dr. Frazier and some of his public health students started an intensive survey of university campuses. Not only did the group identify the violations, but they took a practical approach and gave specific locations on different campuses and recommended how to comply with OSHA.

Discrepancies

1. Fire Protection - Portable fire extinguishers required by OSHA 1910.157
2. Flammable Storage
3. Storage Compatibility
4. Egress
5. Storage under Stairways
6. Electrical Circuit Grounding
7. Electrical Equipment Grounding
8. Machine Guarding
9. Laboratory Refrigerators
10. Compressed Gas Storage
11. Laboratory Fume Hoods
12. Safety Shower & Eye Lavage - Dry Run and use Eyewash
13. Medical Surveliance - Medical consultant due to nature of work
14. Welding & Brazing - Places had no proper eye protection

So you see, no longer can we, like the ostrich, put our heads in the sand and think lab safety will happen. Lab safety is not a game of chance - We must stack the deck.

I would like to close in the words of Dr. Frazier, "Helping students become aware of hazards and the means of and for protecting their health before they enter the work force could stimulate great improvements in industrial health programs."

Polymer Chemistry in Industry

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Presented to a Symposium on Polymer Chemistry at the Fifty First, Two-Year College Chemistry Conference, City College of San Francisco, San Francisco, August 28, 1976.

INTRODUCTION

The purpose of this presentation is to speak briefly on the subject of the importance of polymer chemistry in industry by pointing out some ways in which polymers and knowledge about them are exploited. Magnetic tape will be used as a specialized example. Suggestions will be made as to some polymer concepts that might be added to the two-year college curriculum to fill what would appear to be a need in this area.

IMPORTANCE OF POLYMERS

Polymers are vital to biological life itself and are part of our everyday living through providing fulfillment of many basic needs and desire for conveniences.

Major industries based on polymers are listed in Table 1. Examples will be given to illustrate the significance of polymer properties in each category.

TABLE 1

MAJOR INDUSTRIES BASED ON POLYMERS

FIBERS
PLASTICS
FILMS
ELASTOMERS
COATINGS
ADHESIVES

Trends and current emphasis in commercial polymer development (Table 2) relate to finding new uses and properties as well as meeting more stringent requirements for safe and ecologically suitable products.

TABLE 2

CURRENT EMPHASIS AND OPPORTUNITIES

NEW PROPERTIES, NOT NEW COMPOUNDS

greater stiffness, strength, loadbearing capability
thermal stability

MEETING GOVERNMENT REGULATIONS

ENVIRONMENTAL PROTECTION AND SAFETY

toxicity, flame retardance, low smoke generation, degradability

NEW APPLICATIONS

NEW PROCESSING METHODS

energy and raw material savings

OTHER ENERGY SAVINGS

automobile part weight reduction by plastics

BETTER PERFORMANCE AT LOWER COST --- REPLACEMENTS FOR

wood, metal, paper, glass

ACTIVITIES REQUIRING POLYMER KNOWLEDGE

There are many ways in which an industrial polymer chemist functions besides synthesis of new materials. The needs for polymer knowledge are extensive in a variety of activities and these will be described in terms of the steps required to develop a polymer from the idea stage to sales (Table 3).

TABLE 3

ACTIVITIES INVOLVED IN TAKING A NEW PRODUCT TO MARKET

MARKET RESEARCH - IDEA GENERATION

INFORMATION RETRIEVAL

CHEMICAL SYNTHESIS

SEPARATIONS

ANALYSIS

TESTING -- PHYSICAL, CHEMICAL, MECHANICAL, TOXICOLOGICAL

APPLICATIONS RESEARCH

PROCESS ENGINEERING

FIELD TESTING. MARKET DEVELOPMENT

PRODUCTION

SALES

POLYMER PROPERTIES

There are a great number of physical and mechanical tests as well as chemical properties that are of importance to evaluate in order to assess the value of a polymer in a given practical application (see Table 4). Regretfully, much of the chemist's basic exposure to and understanding of the meaning and significance of these parameters is postponed until he enters an industry in which these concepts are applied.

TABLE 4

SOME PROPERTIES OF INTEREST TO POLYMER SCIENTISTS

- MELTING POINT, TRANSITIONS
- MOLECULAR WEIGHT
- MOLECULAR WEIGHT DISTRIBUTION
- CRYSTALLINITY
- MELT VISCOSITY
- SOLUBILITY
- SOLUTION VISCOSITIES
- TENSILE PROPERTIES - VISCOELASTIC PROPERTIES
  - Modulus, Elasticity, Flexibility, Toughness, Softness/Hardness, Stress-Relaxation, Creep, Damping Characteristics
- CHEMICAL PROPERTIES
- APPEARANCE, FEEL, ETC.
- DIELECTRIC PROPERTIES
- THERMAL BEHAVIOR
- SURFACE ENERGY, POLARITY

POLYMER APPLICATIONS IN MAGNETIC TAPE

Polymers are extremely important in the manufacture of magnetic tape (Table 5), the most important polymeric components being the base film and the binders for the magnetic material. Consideration will be given to the above properties in describing how these materials are selected.

TABLE 5

POLYMER APPLICATIONS IN MAGNETIC TAPE

- BASE FILM
- COATINGS
  - Binders
  - Dispersants
  - Additives -- Lubricants, Stabilizers, etc.

TABLE 5 (con'd.)

PROCESSING AIDS

PLASTICS

- Reels
- Tape Systems
- Shipping Containers
- Accessories, Parts

SUGGESTIONS FOR TWO-YEAR COLLEGE CURRICULUM

The organic chemistry course apparently affords the student some introduction to the chemistry of several commercially important polymer syntheses. Perhaps additional insight on basic polymer properties would be in order at this level through discussion of some principles of polymer physical chemistry and mechanical properties.

Second Year Chemistry — Role of Quantitative Analysis

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Presented to an Effective Teaching Symposium at the Fifty-First, Two-Year College Chemistry Conference, City College of San Francisco, San Francisco, Calif. August 27, 1976.

I must confess, at the outset, that I have no first-hand experience with the teaching of quantitative analysis in a two-year college. On the other hand, I would wager that the role played by, and the problems associated with the teaching of quantitative analysis in a community college have much in common with the same enterprise in the State University and College System. It is in the latter context that I would like to offer some observations, in the hope that they can be extrapolated into the former.

In my view, the proper role of the quantitative analysis lecture can be defined in terms of bounds, with neither of which am I in sympathy.

On the one hand, there has been a trend in recent years to incorporate much (if not all) of quantitative analysis into the first year chemistry course. I believe that this is unfortunate. First and foremost, there really is no need to introduce more material into an already crowded first-year curriculum. Second, I believe that the subject matter is sufficiently important to justify the existance of quantitative analysis as a

separate course. Ideally, I believe that analytical chemistry should be taught by analytical chemists, even as other branches of chemistry tend to be the province of those who have been trained in the particular field. Even if this ideal cannot be met, I submit that a separate course in quantitative analysis has a place in the curriculum if for no other reason than to provide a much-needed opportunity for the student to review and expand upon important concepts - specifically chemical equilibrium and stoichiometry. A working knowledge of these concepts is frequently lost in the welter of topics presented in the first-year course.

Although it may be inefficient for the highly gifted student, the repetition of the material in the two courses does more good than harm for the majority. In this one respect, quantitative analysis is filling a function that qualitative analysis did in an earlier day when that course was still a part of the chemical curriculum.

On the other hand, I feel it equally important to resist the temptation to tailor the content of a quantitative analysis course strictly to the needs of chemistry majors. In short, we should never lose sight of the role that quantitative analysis plays as a service course for many students whose major objectives lie outside the confines of chemistry. Let me illustrate with some data, which I suspect are typical: in the last four semesters (Fall 74 - Spring 76) I have had a total of 233 students in quantitative analysis. Of this number, only 50 had declared chemistry as their major; in fact, many of these 50 were actually premedical students. The largest group in the 233 were students majoring in some branch of the biological sciences. Clearly, then, it is not in the best interests of the majority:

(1) to teach the course on the assumption that one's audience has an all-consuming interest in chemistry

or

(2) to set prerequisite requirements that would permit, at one stroke, a more sophisticated presentation, but would also greatly decrease the number of students with the necessary background for this course.

Permit me to defer some observations regarding course content for a moment.

If there is anything easier to justify than the lecture portion of the quantitative analysis course, it has to be the laboratory. Here success is much the result of painstaking care, where such is needed, as it is upon a knowledge of the principles upon which the analysis is based.

One ingredient of success in the laboratory is an appreciation of the operations and measurements that must be performed with great care, as distinct from those for which approximations are perfectly satisfactory. Such judgments come

from an understanding of the basis for the experiment. The other ingredient is the physical dexterity required to perform these operations and measurements. It is a relatively rare individual who possesses an abundance of both qualities. More often, the person for whom the principles are straightforward finds the practical application of these principles difficult. Conversely, one frequently encounters students who have a poor grasp of what they are doing in the laboratory, but they nevertheless do it exceptionally well.

The laboratory portion of a quantitative analysis course also provides an excellent opportunity to train students in the matter of objective observation. The time invested in the laboratory is well spent if, at the end the student has become more willing to report things as they are, rather than as he would like them to be. This is excellent training for any endeavor.

So much for roles. Permit me to share with you some notions with regard to course content. First, the lecture: As suggested earlier, I believe that chemical equilibrium and stoichiometry are the two main themes that should pervade the lecture.

In the matter of equilibrium, I believe that there are at least three goals to strive for.

(1) In the first place, students should be encouraged to use approximations wherever such use is justified. This is not appreciably different from their previous exposure, but a point that should be continuously emphasized.

(2) Second, the attempt should be made to provide the student with an appreciation of the circumstances where the ordinary assumptions are likely to give misleading answers, as well as methods for solutions of such problems.

(3) Finally, equilibrium calculations in systems involving complex-formation and oxidation-reduction should be presented and explored in detail.

There frequently is a great need for drill with equilibrium calculations, even with the uncomplicated types that were discussed in the first year. If this sounds like an indictment of dereliction on the part of those who teach freshman chemistry, let me hasten to add that, after we have devoted an inordinate amount of time to acid-base equilibrium in quant, the biochemists fault us for sending them students whose training in this realm is grossly inadequate. We always respond that the students in question must have transferred in as juniors, but of course this is not necessarily true. The sad fact is that the carry-over from one course to another is discouragingly small.

We are entering a period of transition inso far as stoichiometric calculations are concerned. There is little doubt that the units, as defined by the International Bureau of Weights and Measures, will ultimately become the only acceptable way to

describe the amount of material in chemical terms. For the time being, however, (and for the forseeable future, insofar as the chemical literature to date has value), the gram-formula weight and the gram-equivalent weight will also be encountered and should be given at least limited discussion. It is hard to teach old dogs new tricks. It may be that the SI recommendation with regard to the mole will be less taught with uncertainty than the schemes heretofore in use; I remain to be convinced.

In this connection, I would like to see the total elimination of the equivalent insofar as it remains with us from the first-year course. It seems that the broadening of this notion in quantitative analysis requires a lot of unlearning (or else resistance bordering on rebellion) on the part of many.

What, then, about the laboratory? Without minimizing for an instant the growing importance of instrumentation in modern analysis, I believe that for the forseeable future "classical" methods will retain much of their importance. It can be further argued that instruments are involved only in the final measurement, and that the operations that proceeds this measurement are not likely to differ significantly from those that precede a final measurement based on a weight or a volume.

For a first exposure to quantitative analysis, I am inclined to limit experiments requiring instruments to those involving potentiometry, spectrophotometry in the visible region, and perhaps atomic absorption. Discussion of principles should precede the use of any of these instruments; one could scarcely hope to have the time to consider others.

While excellent arguments can be proposed for both views, I believe that the limitation of laboratory time and/or penalties for extra time are profitable and more equitable than an "open" laboratory. Similarly, I believe that performance with a method of established reliability upon a sample of known composition is the only way whereby proficiency in laboratory skills can be measured. After these skills have been clearly demonstrated, innovative work can be considered and in fact encouraged.

In summary, then, I am convinced that quantitative analysis has a role in the first two years and that it is likely to retain this role for the forseeable future. I am equally convinced that the proper location for the material of this course is in the second year where it can be of the greatest use to the greatest number.

High School — Community College Relations

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Is there really a need for better communication between high school and college chemistry teachers? At least one of

my colleagues feels that what has happened to a student in the high school doesn't really make any difference as far as his performance in freshman chemistry is concerned. Yet there are others who feel that good communication between high school and college chemistry faculty can be a real benefit. Having taught chemistry in high school for six years and in the community college for two years, my experience leads me to agree that better communication between the two groups can be beneficial.

The faculty at Mohawk Valley Community College is involved in several activities in the interest of good relations with secondary school teachers. The chairman of the Chemistry Department is involved with the Mohawk Valley Science Teachers Association, an organization of secondary school science teachers. He, in fact, holds an office in this organization and has directed his efforts toward planning activities that will interest and benefit secondary science teachers. One of our other faculty members has presented a talk at a meeting of this organization. This same faculty member is also advisor to the Student Affiliates of the American Chemical Society. This organization schedules speakers and seminars on various topics in science and high school teachers and interested students are invited to attend. Another of our professors has put together a "Magic of Chemistry" show. He and our technical assistant visit area schools and present this show in science classes. Some of us have made ourselves available as tutors as Regents time (New York State) approaches. This relieves some of the pressure for the teacher and the student and cements good relations. Another team of instructors has visited area high school classes and discussed the chemistry-related programs offered at Mohawk Valley Community College.

It can be seen that things are being done toward the end of better college-high school relations. However, these activities do not really involve two-way communication. I would like to suggest activities that would improve the two-wayness of communication. We might make a start by obtaining the names and addresses of all the high school chemistry teachers in the immediate area. Once having this, a dinner meeting could be planned inviting the chemistry teachers on the compiled list. The format of the meeting might well be cocktails-dinner-discussion so as to allow for some people to people interaction to take place before any formal discussion occurs. During the discussion period, with a clever moderator in charge to keep personal gripes to a minimum, problems and needs could be revealed. From that, there can be brainstorming for ideas on how to go in a positive direction.

Many good things can come from such a meeting as this, but to zero in on them, we could have a kind of evaluation or follow up form. This could be used as a tool for gathering data, identifying problems and approaching the answer to the question, "Where do we go from here?" The group, of course, would determine the outcome. Others who have experimented with this idea, tell me that from their meetings have come results such as monthly newsletters, pooling of budgets to obtain discounts, and

touring of each others facilities. Regardless what the group decided to do, a step would have been taken to open up two-way communication between high school and college chemistry teachers. It would seem that with that door open, many problems would be solved or at least better understood.

Chem 13 News — Talking about Chemistry Across the High School — University Gap

Reg Frieson
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Presented as a part of a symposium on Innovations in Communicating Chemistry at the Fifty-Fourth, Two Year College Chemistry Conference, Brandywine College, Wilmington, Delaware, April 23, 1977.

Back in 1968 when students were plentiful and standards by which they were evaluated were common to large groups of schools, I began to discuss with George Atkinson and Pete McBryde the desirability of setting up a newsletter for Ontario Chemistry teachers in high schools. CHEM Study was just being introduced into Ontario high schools, and province-wide examinations were being discontinued. We thought that a short, not-too-stuffy newsletter might be useful. It was to carry information, advice and comments on the sections of the new chemistry curriculum. We distributed one copy to each of 650 Ontario high schools and invited chemistry teachers to place their names on a permanent mailing list. We were surprised and pleased to find that we quickly had a list of over 1000 names. Teachers evidently liked the idea of the newsletter.

In the first few years, we published ten issues each year. We kept getting approving comments, but not nearly the quantity of publishable letters and articles by teachers that we had hoped for. Jack Candido, Head of Science of Kitchener-Waterloo Collegiate and Vocational Institute, joined Pete McBryde and myself as editors. Having a classroom chemistry teacher as a reviewer of articles and books and a helper in assembly and layout and proofreading is a very good thing.

Here's an overview of what CHEM 13 NEWS is now like:

The magazine or newsletter usually runs to 16 to 20 pages. We carry short articles by teachers and university people on both chemical content and methodology. We don't insist that contributions be original, but we ask, "Are they likely to be useful to Ontario chemistry teachers?" We like to run ideas for experiments because that's what we think chemistry is about. A typical issue has a page of book reviews, with a rating of usefulness to chemistry teachers; letters to the editors, news about meetings on chemical education (sometimes interesting ACS meeting abstracts are reprinted), a lab safety column, a chemical stamp column, questions and answers, and ads and announcements about books, teaching aids and courses for chemistry teachers.

Who's at the receiving end of all this information? Our

mailing list, which is open only to those who ask specifically to be put on it, has about 1900 Ontario names on it, with another thousand elsewhere in Canada. We carry about 1100 U.S. names and about 200 elsewhere in the world. Most of our readers are chemistry teachers, but a few hundred are college and university types trying to find out what we are doing.

We produce CHEM 13 NEWS at the University of Waterloo by preparing camera-ready copy on an IBM typewriter. We do our own layout and the printer spends between five and ten days preparing negatives and plates for offset printing, printing, collating and saddle-stitching. I then round up a team of helpful students, five or six, and we spend 45 minutes attaching 4300 labels. Our mail room is adjacent to the print shop, so we have no shipping delays.

One full time secretary, working from a tiny office, handles all the correspondence, mailing list maintenance, bills and donations, typing of the issue and all other activities associated with CHEM 13 NEWS. Our costs add up to about $17,000 per annum, and the biggest items are printing, salary and postage. In each issue we report donations from readers.

Our Chemistry Department is pleased with the reputation the newsletter has been earning, and there are no plans to curtail the operation.

A similar newsletter is published less frequently for Physics teachers. One issue of BIO 13 NEWS has been produced by the chemistry and physics editors, faute de mieux.

SCIENCE/WATERLOO

In 1969 our faculty of science planned, with Don Garratt, who is Science Coordinator to the Scarborough Board of Education, the first of a long series of day visits by high school science students to the University of Waterloo. Our aim was to give high school students a direct experience of what university learning in science is like, by inviting visitor students to sit in on ordinary freshman classes and to perform excerpts from freshman labs. We called the program, SCIENCE/WATERLOO, and we've been running it in a big way each year. Eighteen Fridays are designated SCIENCE/WATERLOO days each academic year, and four to five thousand science students from about 140 high schools visit us. Visitors choose their own timetables from one distributed ten days before the visit. Busses are met at the university entrance, last-minute announcements are made, and the students are on their own, equipped with timetables and maps.

We're delighted that the same schools keep bringing their students year after year. We take that as evidence that teachers and students find the program to be worthwhile.

I may have two to ten teachers as my lunch guests on a typical Friday. We do a lot of talking about problems of content rationalization between schools and universities, and about standards and where skills are going; we argue and trade opinions. I hear comments about what the teachers see us, the profs,

doing in our freshman classes - often comments of surprise that it is necessary to repeat so much high school material. We talk about admission policies and procedures, and about high school graduates and how they're faring.

SATURDAY SEMINARS

From 1970 to the present, various Departments in the faculty of science of the University of Waterloo have been staging day-long seminars on a Saturday in April. The topics are for chemistry, largely chosen for the portability of ideas and experiments back to the school classroom. We have had a try at content updating also. On April 30 we expect about 120 science teachers and 40 senior students to visit us for a day of lectures and labs on origins of the solar system, the earth, precursors of living matter, and life itself. We emphasize the preparation of handouts on a generous scale. There's extensive interaction between visitors and university faculty.

SHELL MERIT FELLOWSHIPS

Since 1970 Dave Humphreys, McMaster University, has been running 4-week sessions in July for about 20 chemistry teachers from across Canada. With the help of generous support from Shell Oil, teachers assemble for updating lectures and an opportunity to work on the preparation of teaching aids. Again, opportunity for the exchange of views and information is extensive and the opportunities are used.

CORRESPONDENCE COURSES

Correspondence courses in science, in an audio-tape and notes format have been a characteristic of Waterloo's outreach for several years. Many Ontario chemistry teachers have been our students, at least part of the time, while they have been upgrading their qualifications.

CHEM 13 NEWS RESEARCH ASSISTANTSHIP EXAM

With a part of the earnings from running correspondence courses for teachers, our Chemistry Department set up a province-wide competitive exam for high school chemistry students. When the exam is written on May 5, we'll probably have 6000 students from 420 schools participating. We publish and publicize the names of the high achievers and we invite top students to participate in research assistantships before and during their first year of study at the university. The University of Toronto Department of Chemical Engineering is, and the McMaster University Department of Chemistry has been, a collaborator in funding this exam.

RESEARCH ASSISTANTSHIPS

The research assistantships themselves consist of a student's working with a professor or his research group on an investigation which may be part of the professor's regular research or it may be a special project. The student spends 3 or 4 hours per week at the work, in addition to his regular academic load.

LEARNING PROBLEMS IN CHEMISTRY

Informal Testing for Formal Thinking

Jane Copes
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Presented as a workshop at the Fifty-Fourth, Two-Year College Chemistry Conference, Brandywine College, Wilmington, Delaware, April 23, 1977.

All of us share the frustration of having students who just won't (or can't) understand our crystal-clear explanations of complex (and sometimes simpler) phenomena in chemistry. We deal with that frustration in various ways: by writing off those students as "dumb", by returning to the beginning with them, by "proofs by loud voice", by blaming ourselves, or sometimes by trying out the philosophical and/or practical ideas of others. This latter solution has led me to a fascination with the ideas of Jean Piaget's developmental scale as applied to chemistry teaching and learning.[1-5] Several excellent sources are available for your conversion.

The workshop on Saturday afternoon will offer you a chance to share ideas on various styles of testing for formal operations. Apparatus for the classical "Piaget tasks" will be available for your experimentation. In addition, we will generate and share suggestions for possible pencil and paper tests. I've found that a combination of a low-pressure, informal written test (that also assesses arithmetic and algebra preparation) and careful watching and questioning of students' work in the laboratory (on several carefully designed experiments) helps me learn most about my students' reasoning patterns. And knowing more about my students increases my patience level by several orders of magnitude.

I hope you'll come to share and learn with us.

"THE ENEMY IS US" -- Pogo (with liberties)

Over the past few years, a number of highly digestible, well-written, and even proselytic articles on the significance of Jean Piaget's developmental scheme to science teaching[1-5] have caught my eye. I have enthusiastically passed these ideas and articles on to my colleagues and have been met with two basic reactions: AHA! and SO WHAT? I hope that my audience includes some of each of these groups; let's explore a bit more what each group has to offer.

The AHA! group includes people much like me (so they must be right, right?): puzzles about how even the most crystal-clear explanations of density, moles, equilibrium, and sometimes even area, produce clouded countenances and poor exam scores. Those of us who have responded AHA-ly to Piaget's ideas are searching for ways to get through to more students. But we converts can become too evangelical. Will Piaget's ideas really tell us how

to teach 'better" and help us produce more formal thinkers? What difference does it make if we can identify early in our courses the students who will probably have troublt anyway? Should we try to change our students' reasoning modes?

My so what colleagues puzzle me; they're not like me (although I have had my share of so what responses -- high school geometry, the fundamental theorem of calculus, sociology, etc.). When I bring to them what I am convinced is an ideal gas-tight argument (see below) for changing our teaching styles, they reply, with varying degrees of hostility, "That can't be so. Of course my students understand what 'per' means!" or "Maybe they don't grasp the true significance of the concept of area, but they can be taught (emphasis mine) to work problems, can't they?" Corollary comments are that either "those people" don't belong in college science courses anyway or that they're "just stupid". I'm afraid that my so what colleagues tend to proofs by loud voice, and I usually retreat as our respective blood pressures rise. I'm becoming more pessimistic about my powers of persuasion.

Yet the so what folks aren't entirely to blame. Like all of us, they need to feel successful at teaching to keep coming back to the classroom day after day. I happen to think that they are less perceptive of their students' strengths and especially weaknesses than they could be. But it is less painful not to realize the depth of those blank stares. At times I wish for a return to that innocence.

So much for a description of the two groups of people in the world. What are we arguing about, anyway?

THE IDEAL GAS-TIGHT ARGUMENT

In brief: (1) Understanding science demands some facility with formal reasoning, in Piaget's sense of the word. (2) Most teachers and curriculum materials assume that college science students are reasoning formally. We teach as if our students can really grasp and use hypothetico-deductive reasoning, the foundation of our "scientific method". (3) Most of our students aren't reasoning formally. (4) If the foregoing statements are reliable, and if we are going to accept the students who apply to our institutions, then some changes are vital. As science teachers, we must rework our methods, our assumptions, and our very vocabularies to deal with the real students we are asked to teach.

To elaborate on (1) and (2): Formal thinking has much to do with being able to work with the form of an argument apart from its content. For a formal thinker, there is a great deal of similarity between

All women are mortal.		All gergs are vrap.
George Eliot is a woman.	and	Glip is a gerg.
George Eliot is mortal.		Glip is vrap.

The content doesn't much matter; the forms are the same.

Formal thinkers understand and use "if-then" relationships comfortably and aren't stumped by simple contrapositive argu-

ments. If you're still not convinced that science uses formal patterns of thought and that we assume that our students use them, just open your current text and count the number of "if-thens". For example, consider the usual atomic theory development. "If the atom were like this, our experiments should give these results. We didn't get those results. The atom must not be the way we first thought!" Thud. We expect our students to be able to isolate variables in laboratory investigations and ignore extraneous information in word problems. Some of us may be in for some surprises.

(3) Most of our students simply don't think consistently in formal patterns. That doesn't in any sense make them stupid. The beauty of Piaget's scheme is that it speaks of development, growth from more rigid patterns of thought and behavior to ones that are freer and more able to deal with complex data.

Piaget's interviews with Swiss children placed most of his 13-15 year olds in the formal stage. An overwhelming amount of research[6-8] in this country and elsewhere points out that a sizable number of our early college students and even some senior science majors and (particularly painful) elementary school teachers are not reasoning formally. Although I am not in the least interested in amassing impeccable statistics, results of my informal tests with my students show that at best 10% of them are consistently formal. Nonformal thinkers have trouble planning an experiment to isolate variables, they tend to investigate randomly and keep inadequate records of their experiments, they understand derived units (density, velocity, heat capacity, etc.) poorly, and above all, they reason haltingly without actually manipulating concrete objects. And some of our colleges are trying to cut costs by cutting back on lab time!!

Before expanding on point (4) above (implications for our day-to-day activities in college science courses), let's look at some possible ways of learning more about our students' major modes of reasoning.

TESTING, TESTING

Jean Piaget is a master of the conversation-interview technique of learning about the child's perception of the universe. His developmental scheme and refinements have come directly from his observations of hundreds of young children. Piaget used a number of tasks and hypothetical situations to learn from his child friends about their views of the physical and moral worlds around them.[9] Although the ages vary at which different children reach the stages (pre-operational, concrete, and formal operational), the order of steps does not.

The direct interview technique has some applications to college students, although I have some reservations about this approach. Let's look at some of the tasks and categories of investigations that may give us some insight into concrete versus formal thinking styles.

One classification of tasks is conservation, the realization that a characteristic of an object such as the length of a stick

is left invariant under a transformation such as moving the stick. The most elementary of conservations is probably that of number; six blocks are six no matter how they are arranged in space. Conservation of solid amount may be investigated by asking a child whether a ball of clay or the pancake or snake made from the clay has more, less, or the same amount of clay.

A similar problem dealing with the conservation of liquid amount involves pouring liquid from a tall cylinder into a wider bowl. Failure of small children to conserve liquid amount has saved many a parent when the juice supply runs low; a two year old is often content with "more" served in a smaller glass. Conservation of liquid amount may be assessed from a more sophisticated point of view with a separatory funnel draining into a beaker. Ask students where the liquid level in the beaker will be when the funnel is half empty, etc.

Length, area, and volume conservations can also be investigated with simple equipment. Children younger than about 7 have trouble ordering sticks of different lengths because they don't focus on both ends at once. They may say that a car has travelled farther than another even though it started at a different place.

path 1 _____

path 2 _____

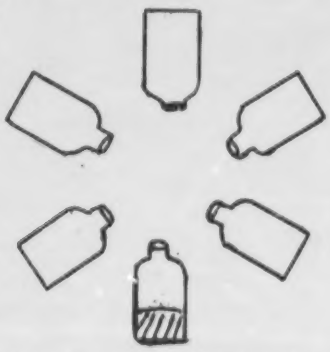
Although area is seemingly a simple extension of length into two dimensions, many college-age students do not reliably conserve area when asked to calculate the areas of a rectangle and the parallelogram made from it.

Conservation of volume under a simple transformations is also a relatively late-developing concept. One possible question is to ask about the volume of liquid in a tall cylinder as compared with the volume of the same liquid in a flat dish. Often, however, the word "volume" is interpreted as "amount", a concept which is conserved much earlier than volume. Another check on this concept is the volume-by-displacement experiment. Many students even at the college level are unfamiliar with the Archimedean principle and will err in guessing the amount of water displaced by metal cylinders of the same size, but different masses.

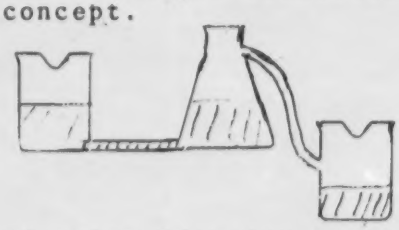
One last single concept is mass conservation. It also is generally assessed with clay balls and smakes or pancakes. This conservation is generally attained by age 11 or 1w, but my students often have trouble with mass difference measurements.

Finding the mass of container plus sample before and after a reaction, and then determining the mass difference of just the sample is a problem for them. Students "can be taught" to do this with well-designed data sheets, but they don't understand the concept well enough to be able to solve the problem themselves. This difficulty may be a symptom of inadequate mass conservation.

A concept which may be related to conservation is the invariance of the horizontal surface of still liquid. Asking students to draw in the water level as a capped jar partly full of water is slowly rotated may generate some interesting answers. A recent experiment with college students showed that a large proportion of college women do not understand this principle.[10]



Experiments with the level of liquid in connected containers may also help assess this concept.



Conservation of derived units (density, velocity, etc.) comes even later in a person's development. Even after a student understands the conservation of mass and volume separately, his or her conception of their ratio (density) is often still very shakey. Most of my students didn't predict that two objects made of the same material would have the same density, and furthermore, still didn't "conserve density" if their experimental measurements were as little as .01 units different.

Along with conservation, ratio-sense is an important part of formal operations. Ratio and proportion methods of working problems are often used in our science classes, but people not yet reasoning formally have a great deal of difficulty with these concepts. A beam balance illustrates the necessity of dealing with both mass and distance from the fulcrum in a multiplicative rather than additive sense. I had a surprise in presenting the problem of an unbalanced teeter-tooter to my nursing students. Even though very few of them appeared to be formal thinkers by other assessments, most of them are mothers, and they solved the problem easily. Experience does play an important role!

Asking students to measure lengths with units of different sizes (small and large stick figures measured with small and large paper clips is the classical task) can also reveal those with "ratio-deafness".[11] Is it any wonder that metric conversions are difficult for these folks?

The "fishermen" problem is a task used to illustrate the concept of ratios of several variables. Flexible metal and wooden rods of different lenghts, cross sectional areas, and composition project from a supporting "wall". Onto these rods are slipped washers or rubber stoppers (the "fishers") of different masses. The problem is to slide all the "fishers" to positions such that their feet just touch the "water". This several variable problem concerns the relationships among distance from the wall, flexibility of the rods, and the mass of the object on the rod.

Isolating variables is another concept with which concrete thinkers have trouble. Two of the classical problems involve the period of a pendulum and hauling a weight up an inclined plane. In each case, students are given appropriate equipment and asked to determine what variables are important. Students who experiment carefully, changing one variable at a time, are probably reasoning more formally. Students' justifications for their responses are also important indicators of reasoning styles.

Methods of experimentation are also good indicators of degrees of formal reasoning. The bottle-mixing (find which combination of substances from five bottles gives a color) and unlabeled bottle (given a list of substances, determine which is in which bottle) problems offer excellent chances to observe how students solve problems. Random, unrecorded trials are light-years away from the careful, try-all-possibilities-and-record-results method we would hope all our students use.

The tasks described above involving conservation, ratio and proportion use, and careful experimentation seem closely related to the formal reasoning abilities we expect students in our courses to have. Other clues to a student's reasoning style include the ability to draw conclusions from data, eliminate contradictions or paradoxes in thought or physical experiments, ignore extraneous information, and deal with nonsense variables.

The interview method is only one of several ways of assessing these abilities, and it does have several limitations. In the first place, how many of us have the time, energy, or equipment to undertake such an evaluation program with even ten students? Few of us are skilled in the techniques of interviewing that would allow us to learn best from this style of interaction. In addition, many of our students (who are, after all, adults) may well be offended at being asked to play with "kids' stuff".

Pencil-and-paper tests are a logical extension of the interview technique. The instructor could explain the situations to an entire class and ask the students to write down their responses. This method has serious limitations for our non-verbal

students, and it still does not eliminate the problem of offending adults. Although developing "the best" pencil and paper test of Piaget level is a noble aim, to suggest that with enough research, someone will develop a machine-scorable test useful in all situations is naive at best.

I have had considerable success with a quite informal method of testing for the extremes in the concrete-formal spectrum with my community college students in general chemistry and organic courses. The test involves simple modifications of the mathematics pre-test which nearly all of us use as a part of our first day activities. I'm still interested in identifying the students whose arithmetic and algebra skills are in disrepair, so I include a section of straightforward non-word problems. But why not slip in an area conservation problem? A square can be cut and rearranged into many different geometric figures, the areas of which are the same as that of the original square. Consider problems with nonsense variables, extraneous data, or even syllogisms, especially the emotionally-loaded variety. Include a question such as "If you are stuck, what information would you ask for?" Comments can be quite revealing!

I have encountered some problems with students who are terrified of even informal testing and freeze on the problems they know well how to work. You should stress that the test won't be graded, but you might also intersperse personal data questions (name, other activities, experience in science, etc.) with the other questions to ease some of the pressure. Perhaps avoiding the word "test" altogether will also help. Don't be tempted to give such a survey without your supervision, because even in non-threatening situations, students will get "help" from family and friends. Three of my star formal thinkers had developed severe relapses by the first lab period.

In addition to the pre-test, I've found that careful observation and questioning of students in lab is incredibly revealing of "Piaget level". I've used an experiment on masses, volumes, and densities for the first lab of the year and am now sure that it is the most useful lab I've ever written for learning about my students' reasoning styles. How your students work on unknowns is also a good indicator of concrete-formal thinking.

The most important thing about this testing, though, is that you must be willing to be surprised. Please don't use the results to categorize students. All of us reason concretely in some fields of our endeavors, especially when we are first learning new tasks. There is also some evidence that children form and lose their conservation abilities several times before the age of ten.[12]

Once you think that you have identified the most concrete and most formal thinkers in your group, keep watching! Play some games with them such as having them guess what element you're thinking of. Non-formal thinkers will very often resort to wild guesses and be upset by "no" answers even when they may have gained as much information as with a "yes". This latter trail may be due more to social conditioning than concrete reasoning.

A good plan is to give one clue and ask for a question from a stu-ent. If the student uses the clue profittably, give another clue. If not, go on to another student. A British game called "Master Mind" is a great diversion for informal gatherings and seems to be a good diagnostic for concrete-formal operations. Keep listening to how your students ask questions and solve problems. There's a lot to learn!

SO WHAT? (Reprise)

Back to point 4; remember point 4? So what if we may be able to tell which of our students aren't reasoning in the ways we expect them to? The painful fact is that we just <u>don't know</u> how to teach in ways that insure that concrete thinkers progress through that necessary stage and learn to function more formally. In addition, we don't know how to teach our non-formal thinkers concepts that are usually understood only by formal thinkers. Dudley Herron suggests a bit more caution in our enthusiasm to absorb Piaget's concepts into our science curricula.[13] He feels that there is more hope for identifying <u>concepts</u> that concrete students may find more difficult than for identifying the <u>students</u> who are not reasoning formally. This idea of concept analysis is certainly an important area for further research. It may help us avoid the possible problem of invading a student's personhood by determining his "level" and trying to change it.

Several projects around the country[14] offer new ideas for changes in our teaching styles. There is some evidence that more concrete experiences offer some help in development toward formal thought.[8] Jenner[15] offers some suggestions for activities that may help young children bridge the gap between pre-operational and concrete operational stages. The pre-operational child seems just as rigid to a second grade teacher as our concrete operational students seem to us! By describing characteristics of formal thought and offering non-threatening opportunities to our students to "try-on" those characteristics may help ease some of our frustrations and those of our students. One thing is certain, however; no one can skip or short-circuit the concrete operations stage, even though we may want to hurry our students along.

THE LAST MOVEMENT (For Further Reflection)

A humbling realization is that even though we might be teaching (telling) our students that the mass of a pendulum bob doesn't affect the per;iod, many of our students haven't learned it (didn't hear) and won't "remember" that fact later.[16] "But I <u>told</u> you! Don't you <u>know</u> it?" can be a frequent refrain from even the most patient teacher. It isn't that these folks don't want to learn or won't listen; they simply can't understand what we're saying yet. They haven't developed the mental structures to deal with the world in the ways we as science teachers expect them to. After all, we don't criticize a small child for not being able to lift a safe; he hasn't developed the physical

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structures yet.

"Yet." That's a most hopeful word, isn't it?

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The Relevance of Current Chemistry Textbooks to Today's Community College Student

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We as chemistry teachers are required to teach chemistry to our students. However, the perennial questions of "what to teach" and "how to teach it" are more difficult to answer than ever before. Specifically, the answer to the question "Which method is best?" may never be found because variety in students demands variety in teaching. To borrow a term from Hubert Youmans, (West Carolina University, N.C.)[1] "Students are differing folk." As such, they do not respond to a single method. Thus, current research in teaching methods aimed at finding the optimum method for all students is doomed to failure. Indeed, in an age of declining enrollment in the physical sciences, when we must be concerned with the recruitment of students from previously untapped sources, perhaps it would be better to develop a number of teaching methods and different kinds of study materials and then match the students, teachers, methods and materials. And once we attract students to our classes, efforts must be made to keep them there, that is, we must reverse the high rate of attrition so common to chemistry classes.

One way to keep students in our classes would be to enhance their chances for successful completion of the course. We all know that nothing succeeds like success. In predicting success

in chemistry, researchers[2] have identified a major characteristic of successful students: they are problem oriented. It is not surprising that their success depends on a number of factors including: (1) verbal comprehension (2) conceptual foresight (3) originality (4) general reasoning (5) numerical facility (6) visualization and (7) motivation.

Now, we know that our typical students do not possess all of the traits just mentioned. In fact, it has been estimated that at most schools, as many as 50% of the students lack the ability to go from verbalized problems to mathematical or symbolic solutions. Thus, a class made up of students with heterogeneous abilities cannot respond to a single so-called optimum method of instruction. It has also been suggested that college science teachers have been using language that their students do not understand and that as a result the students cannot comprehend what is going on in the lecture, laboratory, or textbook situation.

It is apparent that the time is now for educators to become more sensitive to the needs and abilities of the members of their target group and offer a variety of teaching methods and materials. Or, in other words, different strokes for different folks.

One of the most widely used of educational materials is the textbook. Regardless of its traditional association with schooling, the readability of a textbook limits its value. Although readability has been identified as a particularly important factor in textbook selection, schools, and community colleges in particular, have not demonstrated that they have followed suggestions for text selection based on known elements affecting readability. Since the 1920's, researchers have consistently found that the reading difficulty of texts at all levels of science education has surpassed the reading ability of their intended readers. Even recent studies comparing the reading ability of college freshmen and the readability of their textbooks have shown that, in general, texts in use are beyond the comprehension level of many college students. In other words, among the difficulties encountered by chemistry students at community colleges is their inability to adequately comprehend the material in their texts. Researchers investigating the academic deficiencies and study habits of community college students have concluded that many of these students lack skills in the "tools of learning". Many of these students have never acquired such fundamental skills as rapid reading with understanding or managing number concepts in their mathematical relationships.[3] Considering the incompatibility between textbooks and the reading abilities of their intended readers, it is not surprising to find that students have attributed their lack of success at college to slow and inefficient reading.[4]

Previous research has shown that informational achievement is positively related to verbal ability. It has been shown that there is a positive correlation between verbal intelligence and the ability to read in science. While reading ability has always been some measure of vocabulary and sentence structure knowl-

edge, recent research has suggested that comprehension of verbal material might be assisted by the use of certain kinds of drawings. Although the use of illustrations adjunct to science text descriptions has been a common practice in textbook design, the effectiveness of the illustrations has not been adequately studied. Indeed, authors of texts generally rely on intuition rather than the findings of research[5] in the use of illustrations to impart scientific concepts.

The available research on the effect of illustrations in assisting student achievement has not shown consistent results. Samuels, in a review of research related to the effectiveness of pictorial adjuncts to prose descriptions, concluded that . . . "there was almost unanimous agreement that pictures, when used as adjuncts to the printed text, do not facilitata comprehension."[5a] In the field of science education, Dwyer found that varied visual representations of the heart were not effective additions to textual material when texted by verbal questions.[5b]

In contrast to the findings of some of the pictorial experiments, Holliday has shown that a particular kind of visual -- labeled line drawings -- accompanying text descriptions, did facilitate a form of verbal comprehension for both high school biology[6] and junior high school physics students.[8]

In fact, theories from the field of psychology: cue-summation, imagery, and motivation, applied to Holliday's research, support his findings. The theory of cue-summation has proposed that additional stimuli can facilitate learning by contributing to the total number of relevant cues needed for a particular response. The use of drawings directly derived from the information in a text could contribute critical cues needed for a particular response.

According to the results of imagery research,[9] learners have been able to recall about twice as many pictures (in the form of line drawings) or picture-word combinations as verbal descriptions of the same concrete concepts. It has been suggested that pictures are more readily remembered because of the possibility of both verbal and imaginal memory systems, whereas dual memory is less likely with only verbal stimuli.

Finally, according to established work in the field of motivation,[10] certain elements of instruction could increase the attractiveness of the entire learning process which in turn could increase both learner motivation and performance. In other words, educational material which is appealing may be well received rather than rejected by the student group.

In consideration of the inconsistencies reported in the literature about the usefulness of illustrations and because researchers have reported that the reading abilities of community college students are not compatible with the reading levels of their texts, I designed a study to clarify the effects of two instructional techniques on comprehension in chemistry: (1) rewritten textual material and (2) use of labeled line drawings in the presence and absence of the rewritten text. The purpose

of the study was to determine if the comprehension of the content of introductory college chemistry texts would be increased more by improving the readability of the text material or by the introduction of the labeled line drawings with or without improving the readability of the text material.

The topics included in the study materials were both descriptive and quantitative: symbols, formulas, equations on the one hand, and the mole concept on the other. The results indicated that the rewriting of the text passages and not the introduction of the drawings contributed to higher gain scores for the students tested. In fact, the findings in this study are supported by the results of other studies reported in the literature that first, increasing the readability of college level texts improved comprehension[11] and second, that illustrations detract from, rather than enhance descriptions in texts.[12, 13, 14]

While the research findings reported here have indicated that the use of labeled line drawings was not effective in terms of developing student comprehension in chemistry texts for the population studied, the rewriting of the passages, was, particularly for students with below college level reading skills. Since these students appear to have inadequate reading skills for the acquisition of information from traditional chemistry texts, the preparation of specially written texts passages for these students should be initiated.

Newly written texts should be differentiated according to types of writing style specific for both poorer and better readers. This last recommendation is derived from the finding in my study, that with the quantitative passages, the better readers benefitted from the original vocabulary while the poorer readers obtained better results with the rewritten passages. It is essential that we always keep in mind the individual abilities of students and not attempt to teach with only one method or one text. Remember, different strokes for different folks.

One aspect of the text writing process should be the measurement of the readability of the text passages. In measuring reading levels of physical science textbooks, it is imperative that the evaluation take into consideration scientific and mathematical terms as well as ordinary words. While complex formulas are available to accomplish this task,[15, 16] none of the formulas in current use can handle a scientific vocabulary. As a result, reported reading and grade levels are inaccurate. At the very least, text writers should consider chemistry comparable to a foreign language, with a unique vocabulary to be learned, and include a glossary of terms and ample and well distributed definitions for all new terms.

A second consideration in textbook design should be the use of illustrations. Until the nature of useful illustrations is demonstrated by research, illustrations of any kind should be used with caution. Certainly, portraits of scientists at work, or patients in a hospital, or technicians in a laboratory, add little to the understanding of a scientific principle; nor do charts, tables, and graphs that are difficult to decipher. Also,

complicated detailed reproductions may represent advanced photographic techniques, but are these illustrations contributing to information acquisition? Finally, the current use of cartoon style drawings, which are intended to be humorous, may not only contribute little to facilitating understanding, but may be insulting to the readers' intelligence.

In conclusion, further research is needed to understand the special needs of community college students. These investigations should seek to discover the abilities (both verbal and quantitative) and attitudes of community college students. Once these characteristics are known, texts should be designed and evaluated in terms of meeting the special needs of community college students. If these efforts are successful, they may contribute to a reversal of the high attrition rate common in chemistry classes at the community college level.

Please permit me a digression. Besides the task of teaching the various subjects usually found at the community college, these colleges are now being called upon to accept the responsibility for continuing education for adults. I wonder how many of you have had an opportunity to read Dr. Gleazer's article, "A Time to Act,"[17] in the most issue of the Community and Junior College Journal? In it, he identifies four primary skills needed by adults as requirements for living in our society: (1) communication skills (2) computation skills (3) problem solving skills and (4) interpersonal relations skills. Notice that the first three skills are also needed for success in chemistry and the fourth would not hurt. Then, we as chemistry teachers, have the opportunity to provide our students not only with the traditional subject matter, but also with the skills they need to function as competent adults who are scientifically literate. Just as doctors openly favor health, and businessmen promote free enterprise, let educators at the community colleges recommend the proper study of chemistry as preparation for life.

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Cognitive Style Mapping in Chemistry

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Cognitive style is the way an individual searches for meaning. A cognitive style map is a picture of the way an individual searches for meaning. The technique was developed by Dr. Joseph E. Hill and his colleagues at Oakland Community College in Bloomfield, Michigan.[1]

PURPOSE: The technique can be a valuable tool which will enable you to:

1. Know something of your students' personalities, interests and learning styles early in the course.
2. Identify potential problem students and/or behaviors in advance.
3. Individualize instruction for students.
4. Improve learning/study skills of your students.
5. Improve test-taking skills and alleviate test-taking anxiety for your students.
6. Deal in a non-threatening way with student problems.
7. Prepare a "to do" list for yourself.
8. Improve the relevance of your course.

PROCEDURE: To illustrate the mechanics of the technique each member of the audience was asked to complete a "mini" cognitive style mape inventory.[2] The inventory consists of a series of statements regarding certain behaviors; the individual responds with the degree to which the stated behavior resembles his/her own behavior. Some sample questions were:

	Usually	Sometimes	Rarely
1. If I hear the daily news on the radio, I understand it better than if I read it in the newspaper.			
2. I can remember a telephone number once I have heard it.			
3. I prefer maps to verbal directions when I am going to a strange place.			
4. I keep accurate written records in my checkbook.			
5. Random sounds interfere with my ability to concentrate.			
6. A story is easier to understand in a movie than in a book.			

The inventories were than scored, and the resulting cognitive style map was interpreted for the audience.

RESULTS The map is divided into three main sections:

I. SYMBOLS These are items which communicate meaning to you, or which have value for you. They may be:
a. Theoretical (words and numbers, both written and spoken)
b. Sensory (sight, sounds, odors)
c. Cultural codes and values (your "conscience")

II. CULTURAL DETERMINANTS These are the people who influence you. They may be:

a. Individual (yourself)
b. Family (immediate family and teacher as a "father figurre")
c. Associates (friends, co-workers)

III. MODALITIES OF INFERENCE These are the methods you use to process (make sense from) the theoretical and sensory information you have received, after your "conscience" has operated on it and after you have consulted with those who influence you.

a. Organizes (categorizes, defines)
b. Contrasts (sees differences, changes)
c. Relates (associates, synthesizes)
d. Analyzer (questions, appraises, uses all three above methods)

The actual arrangement of the elements in the map and the codes used by Hill are shown in the accompanying diagram. The complete meaning of the symbols is listed in the accompanying table.

Based on the responses to the statements in the inventory, a given behavior is classed as a major element (something you usually rely on), or as a minor element (something you sometimes rely on). A detailed analysis of each element and its utility in the classroom or chemistry laboratory follows.[3]

INTERPRETATION

I. Symbols

a. Theoretical

(1) T(VL) Theoretical Visual Linguistic - Relies on reading words. This person:

(a) likes reading assignments
(b) likes chalkboard use
(c) reads own class notes
(d) reads material prior to the lecture
(e) likes written directions, assignments
(f) likes tests based on textbook
(g) reads lab instructions while you're introducing lab (hand them out in advance)
(h) "sees" page of notes in memory
(i) reads handouts, supplementary readings

(3) $Q_{(S)}$ Qualitative Savory - Relies on taste. This person:

(a) identifies food items by taste
(b) distinguishes chemicals by taste (caution this person about tasting chemicals)

(4) $Q_{(T)}$ Qualitative Tactile - Relies on touching. This person:

(a) likes to get hands on chemical apparatus
(b) is mechanically inclined
(c) does well in chemistry labs
(d) would make good laboratory assistant/laboratory technician
(e) likes to get feel of hybrid orbital models

HINT: If $Q_{(T)}$ is low for prospective MLT students, advise them out of program.

(5) $Q_{(V)}$ Qualitative Visual - Relies on seeing. This person:

(a) likes pictures/diagrams to accompany explanation
(b) likes slides, movies, visual aids
(c) likes to see molecular orbital models (bring them into classroom a week early and let students discover them)
(d) likes chemistry cartoons, Mickey Mouse ears, etc.
(e) distracted by movement during lectures, exams
(f) should study "with blinders on"

c. Cultural Codes and Values

(1) $Q_{(CEM)}$ Qualitative Code Empathetic - Relies on being sensitive to others. This person:

(a) likes to know "where professor is coming from"
(b) is more concerned with feelings than with rules
(c) would enjoy knowing human side of scientists

HINT: Use Asimov's Biographical Encyclopedia of Science and Technology to "humanize" chemistry.

(2) $Q_{(CET)}$

(a) likes structure
(b) likes rules
(c) is bothered when someone else cheats
(d) never cuts class

HINT: Student with low $Q_{(CET)}$ may be a rule-breaker.

(3) $Q_{(CT)}$ Qualitative Code Transactional - Relies on positive interactions which influence others. This person:

HINT: If $T_{(VL)}$ is a minor element (used sometimes), the map can be used to convince student to take remedial reading course. If "the Map" says the student doesn't rely on reading, the student is less threatened and more prone to accept help.

(2) $T_{(AL)}$ Theoretical Auditory Linguistic - Relies on listening to words. This person:

(a) likes listening to radio and television
(b) likes lectures
(c) can follow verbal directions to strange place
(d) likes concepts explained as well as put on the board
(e) "hears" professor explain concept in memory
(f) remembers song lyrics

(3) $T_{(VQ)}$ Theoretical Visual Quantitative - Relies on reading numbers. This person:

(a) likes to talk in formulas $E = E^{\circ} - \frac{RT}{nF} \ln \frac{red.}{ox}$
(b) likes numbers spoken/dictated
(c) adds dictated numbers in head
(d) remembers phone numbers, dates without writing them down
(e) likes problems explained as they are put on the chalkboard

HINT: If prospective chemistry major and MLT is low in both $T_{(VQ)}$ and $T_{(AQ)}$ advise him/her into remedial math or out of the program.

b. Sensory

(1) $Q_{(A)}$ Qualitative Auditory - Relies on sounds. This person:

(a) in classrooms, hears lights hum, radiator clunking, noises outside classroom
(b) is easily distracted by noise in environment
(c) is distracted by noise during exams
(d) should not study with radio or TV on

(2) $Q_{(O)}$ Qualitative Olfactory - Relies on smell. This person:

(a) likes to identify things by smell
(b) distinguishes between chemical odors
(c) would do well in qualitative organic analysis laboratory

(a) likes to manipulate people
(b) will try to talk way out of exams, quizzes

(4) $Q_{(CS)}$ Qualitative Code Synnoetics - Relies on knowledge of self. This person:

(a) knows grade on exam before getting it back
(b) sets realistic goals
(c) knows when to get help

HINT: Student with low $Q_{(CS)}$ will need a lot of positive reinforcement. This student may be conditioned to failure.

II. Cultural Determinants

a. I - Individual - Relies on self

1. enjoys independent study
2. enjoys open labs
3. studies alone
4. won't ask for help (even if in need)
5. will put things "into own words"

b. Family - Relies on family-type settings (not necessarily blood bonds)

1. thinks of faculty as mother/father image
2. discusses matters with family/teacher
3. "high maintenance" student
4. mentions family often
5. studies in family room (may be detrimental)

c. Associates - Relies on peers and/or friends

1. likes small group activities
2. relies on student tutor
3. studies with friends

III. Modalities of Inference

a. M - Magnitude - Makes sense out of categorizing and organizing

1. likes an organized, structured situation
2. likes to memorize definitions and formulas
3. likes to make lists; numbers items in list
4. takes well-organized notes in outline form - often rewrites lecture notes
5. states facts, does not elaborate
6. dislikes rambling, disorganized texts, lectures, instructors
7. keeps desk, room and mind neat and tidy
8. likes to "wrap things up"
9. meets deadlines, on time for appointments

HINT: Course outlines, objectives, textbook should be concise, well-organized for these students.

b. D - Difference - Makes sense out of differences and contrasts

1. likes to find or see differences
2. likes to change things
3. likes true-false questions
4. likes either-or situations
5. wears contrasting clothing
6. notices new hairdo, new suit, rearranged furniture in room
7. says "Let me say that a different way"
8. likes unstructured, flexible situations
9. does better on "contrast" portion of "compare and contrast" questions
10. could easily see how oxidation differs from reduction

HINT: This person may be an excellent instructor, since he/she can explain a concept in several different ways.

c. R - Relationship - Makes sense out of relationships and associations

1. likes to have broad overview
2. likes to relate present learning to past experience
3. likes to synthesize parts into a meaningful whole
4. likes examples
5. wants courses to relate to his/her major field/home life, etc.
6. likes to keep scrapbook relating course work to current events
7. likes examples, worked-out problems in text
8. does better on "compare" portion of "compare and contrast" questions

HINT: Most of our young students and almost all adult students want relevance in their course work. Two excellent sources which can aid the chemistry instructor to increase the relevance of his/her course are:

Hill, John: Chemistry for Changing Times, Burgess Publishing Co.

Asimov, Isaac: Biographical Encyclopedia of Science and Technology.

In addition, the instructors of courses which are prerequisites for advanced courses or courses in another discipline would benefit from actually taking the course his students will enter. This is especially true for chemistry courses for biology majors.

d. L - Appraisal - Makes sense out of appraising using any/all of M, D, and R.

1. likes to question
2. likes to analyze

3. asks "why?"
4. does not like/meet deadlines
5. adds addenda, P.S.'s to papers
6. has difficulty making final decisions
7. reads implications into test questions
8. changes answers on tests
9. never has enough information
10. never throws anything away

HINT: This is the person who re-reads test questions and changes answers usually from the right answer to the wrong one. These students can benefit from recognizing this tendency and its implications.

e. K - Deductive Logic - Reasons deductively

1. likes geometric theorems
2. likes philosophy, logic
3. searches for "givens" in a situation
4. likes to sort out extraneous data

SUMMARY

USE OF MAP	ELEMENTS TO WATCH
1. Know class "personality"	1. Have maps in advance 2. Construct class profile 3. Share your map with students
2. Spot potential problems	1. Low $T_{(VL)}$ to reading clinic 2. High $Q_{(A)}$ study without radio, TV 3. High $Q_{(V)}$ study away from window 4. Low $Q_{(CET)}$ may cut classes, labs 5. Low I needs structure 6. High L changes test answers, procrastinates
3. Individualize instruction	1. A likes small group sessions 2. I likes independent study 3. M likes structure 4. D likes something different 5. R likes relevance 6. $T_{(VL)}$ likes reading assignments 7. $T_{(AL)}$ likes class discussions
4. Improve learning/study skills	1. High $Q_{(A)}$ should not study with radio/TV on 2. High $Q_{(A)}$ should not study near window
5. Improve test-taking skills	1. High $Q_{(A)}$ needs quiet environment

	2. High $Q_{(V)}$ is distracted by movement 3. High L will change answer
6. Deal with problems without threatening	1. "Your map says you don't get as much out of reading as you might"
7. Checklist for instructor	1. Use board $T_{(VL)}$ and $T_{(VQ)}$ 2. Explain as you write $T_{(AL)}$ and $T_{(AQ)}$ 3. Watch organization (M) 4. Use Examples (R)
8. Keep course relevant	1. Use many examples of real life (R) 2. Relate to course for which yours is a prerequisite (R)

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SPECIAL TOPICS TO TEACHING

"The Evolution of Chemistry": A Unique Travel-Study Program

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Presented to a General Session of the Fifty-Sixth, Two-Year College Chemistry Conference, Vincennes University, Vincennes, Indiana, Oct. 7, 1977.

During the summer of 1975, I was a participant in "The Evolution of Chemistry", a unique travel-study program sponsored by Southern Illinois University at Carbondale. Dr. John Wotiz, Professor of Chemistry at Southern Illinois University, has organized and directed this course which has taken the history of chemistry out of the American classroom and into the setting of European universities and laboratories where many major advances in chemistry were developed. This highly successful course was initiated in 1971 and was conducted again in 1973, 1975 and 1977.

This presentation to the Tenth Midwestern Regional Meeting of $2YC_3$ is a brief summary of the 1975 tour. Full details of the program are given in Dr. Wotiz's paper, "The Evolution of Modern Chemistry", J. Chem. Ed., 49, 593 (1972).

The eight-week course consisted of activities related to the history of chemistry. The program sites were located in Great Britain, France, Switzerland, West Germany, Czechoslovakia, Holland and Belgium. Over 35 lectures in the history of chemistry were presented by historians of science, scientists, librarians and museum directors. Extensive tours were made at 20 science and technological museums, 16 universities, the Royal Society, the Royal Institution and several industrial laboratories. The events were scheduled to allow ample opportunity for visitations to other places of cultural interest.

All of the 17 participants in the course had backgrounds in chemistry, and 14 were engaged in teaching chemistry in high schools, junior colleges, colleges or universities. There were also two students who had just completed the Bachelor's degree in chemistry and a retired professor of chemistry. Most areas of the United States were represented, and two teachers came from Ontario, Canada, and Puerto Rico.

One example of "seeing the history of chemistry" can be illustrated with the visit to Giessen, West Germany, where Dr. Claus Leitzmann of Justus Liebig University presented a biography of Liebig in the same lecture hall used by the famous German chemist over a century ago. Dr. Leitzmann then conducted a tour of the Liebig Museum which displays the equipment used by Liebig and his students during the era when Giessen was the world's center for instruction in chemistry.

Besides the wide exposure to the history of chemistry, the value of "The Evolution of Chemistry" is best presented by Dr. Wotiz who writes: "...the students received a better and lasting feel for science as a human endeavor rather than as a manipulation of symbols on the page of a textbook."

Energy Alternatives — U.S. Energy: the Embargo Plus Four

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Presented to a General Session of the Fifty-Sixth Two-Year College Chemistry Conference, Vincennes University, Vincennes, Indiana, Oct. 7, 1977.

Four years ago this month the Arab members of the Organization of Petroleum Exporting Countries placed the embargo on oil sales to the United States. We gave a collective scream of anger, then settled down and began a national effort to protect ourselves from the adverse impacts of that and any similar actions in the future. In quick succession in 1974 the President signed a series of measures designed to bring organization and focus to the energy activities of the Executive Branch and to provide the government comprehensive authority in the development, management, allocation, and conservation of energy resources. Important among these were the establishment in May of the Federal Energy Administration with authority to allocate fuels and regulate prices. The signing in June of the Energy Supply and Environmental Coordination Act (ESECA) authorizing FEA to order power plants using oil and gas to convert to coal, and the authorization in November to collect certain widely scattered federal energy assessment, regulation, research, and development activities into a trio of agencies, the Energy Research and Development Administration (ERDA), the Energy Resources Council, and the Nuclear Regulatory Commission.

By November, barely one year after the embargo was imposed, FEA issued the Project Independence Report, perhaps the most comprehensive energy analysis ever undertaken by the Federal Government. The report provided a blueprint by which the United States could become independent, or nearly so, of foreign energy suppliers by 1985. Achieving the goal, the report pointed out, would require sharply accelerated petroleum and coal development from domestic resources in addition to increased contributions from a variety of alternatives such as solar, geothermal, shale oil, synthetic fuels, and conservation.

While few experts seriously believed that the U.S. could (or even should) expect to become independent of foreign energy sources, the report did help underscore the need for concentrated, sustained attention to seeking solutions to our national energy problems. We have now been at this effort for three years and a legitimate question is "How do we stand with respect to the consumption of fossil fuels and the development of alternatives?"

With regard to consumption, the U.S. used about 2.5% less energy in 1974 than we had in 1973, which incidentally was a record year for the sheer magnitude of energy used in this country, 74.6 quadrillion BTU. The reduction was due to the combined contributions of conservation efforts, higher fuel prices, reduced

economic activity, and a relatively mild winter. In 1975 gross consumption declined another 2.5%, reaching its lowest annual level since 1971. The same factors contributed to the reduction as in the previous year and, in addition, the ratio of gross energy/GNP continued a downward trend begun in 1971 indicating that in some general way the economy was using energy more efficiently.

It was hoped that '74 and '75 had established a trend in evidence of an awakening sense of urgency among Americans. However, amidst this two-year decline of 4.9% from the record energy consumption level of 1973 there were some warning signs that we were not moving quickly enough to reduce consumption and bring alternatives on line. Domestic production of both petroleum and natural gas continued declines that had begun earlier in the '70's and the fraction of our petroleum consumption that was imported continued to rise. Imported crude oil, which had accounted for about 23% of our petroleum needs in 1970, made up about 35% by 1975, and while as recently as 1973 only a small part of our imports came from the Middle East, by 1975 the majority of our foreign oil came from that part of the world.

Unfortunately for all of us, in 1976 our energy consumption jumped 4.8% over 1975, returning to within 0.1% of the record 1973 level. Only conservation efforts, particularly in industry, prevented us from setting another record. Consumption increased for all of the fossil fuels: only the hydropower component of our major energy sources decreased, a consequence of the Western drought.

* Household/Commercial	+7.3%
* Energy for Electricity	+5.6%
* Transportation	+4.2%
* Industrial Energy	+3.3%

Petroleum was again the largest contributor, supplying 47.2% of our national energy, and nearly 40% of that total was imported, primarily from the Middle East. The contribution from natural gas declined by one percent to 27.3%. Coal production reached 665 million tons, a new record, and contributed 18.4% to the total. Nuclear energy's share amounted to 2.8%, up from 2.3% in 1975.

Again as in recent years, 94% of that 74.6 quadrillion BTU came from the fossil fuels -- coal, oil, and natural gas -- with the latter two accounting for 75% of the total. And as you are surely by now aware, our domestic supplies of both oil and natural gas are becoming noticeably less abundant, increasing our dependence on foreign sources, adversely effecting our business activities, and constraining our international affairs and foreign policy options.

Earlier this year a new president, who described the national commitment necessary to solve our energy problems as "the moral equivalent of war", accelerated and modified the focus of federal

actions in the field of energy. He called for and received rapid congressional approval for the elevation of energy policy-making to the cabinet level through the formation of the new Department of Energy, which will open its doors in a few days. In preparation for hearings on the DOE Legislation a team of specialists developed, with considerable public input, the National Energy Plan which outlined in detail the Government's proposals for addressing the energy crisis. The legislation to implement this plan is now before the Senate, having passed the House just prior to the August congressional recess. The result of this debate will have major, long-term impacts on our daily lives.

Clearly, and for reasons in addition to those noted, it is important that we adjust the fuels mix in our energy economu away from continued heavy reliance on oil and natural gas. It would make the most sense to shift the energy mix toward renewable sources, especially solar energy, but, while we wish it were otherwise, the alternatives available to us for the remainder of this century are remarkably few. Some combination of them must be found to make the major BTU contributions that weill be required over the next 15 to 20 years as our domestic oil and gas fields become depleted and to be in place to fuel our nation beyond 2000 AD. We must get our nation through the next quarter century while renewable or extremely long-lived alternatives are developed and, extremely important, we must do so without deliberately or inadvertantly degrading the environment unreasonably for either ourselves or those who will come after us.

The basic foundation of our energy system for the next generation will almost certainly be coal and nuclear fuels, which we have in abundance. In order to prepare for the next century and beyond we must be looking at other things as well; Let's examine coal and some, at least, of these "other things", ie

The Alternatives:

While the Persian Gulf nations may have oil, we have coal, nearly one-quarter of the world's supply. The national energy plan calls for sharp increases in our coal production from last year's record output of 665×10^6 tons to more than 900×10^6 tons by 1985 and 1.2×10^9 tons by 1990. The environmental impacts of that production could be enormous, and for that reason the Congress recently passed and the President signed the Surface Mining Control and Reclamation Act of 1977 designed to prevent at least some of the abuses of the past.

In addition to the controls provided by the legislation, other means of using coal may provide more environmentally safe means of utilizing this resource, e.g. liquifaction, gasification, and MHD generators.

While world and domestic oil supplies are dwindling, very large hydrocarbon reserves exist in the form of the Athabasca Tar Sands in Canada and the Green River Oil Shales in the Western United States.

For a while, of course, imported LNG and crude oil and NG

from Alaska's North Slope and from our considerable off-shore reserves will help, but ultimately a major portion of the nation's electrical power will be generated by nuclear plants. The nuclear component, while not likely to reach the level of earlier projections, is now providing about 4% of our total energy, a number which is steadily increasing. Recent reductions in the rate of planned expansion in this area, however, suggests the possibility of electrical reliability problems in the future. In disagreement with the Administration, the Congress just recently voted to continue full-scale development work on Breeder Reactor Systems. Beyond these systems lies the promise of Hydrogen-Fueled Fusion Reactors such as the Scyllac at Los Alomos.

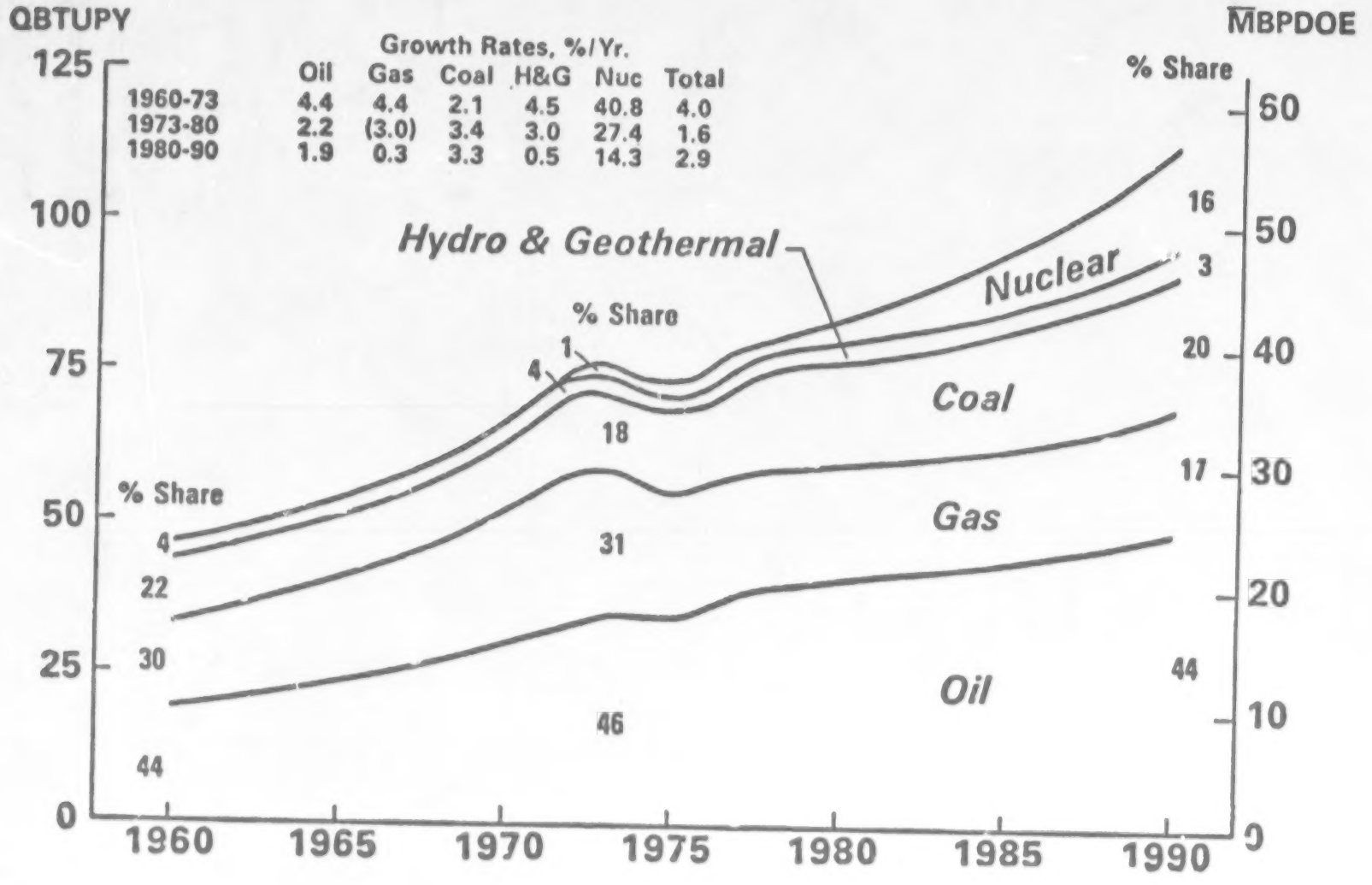
Los Alomos is also a center for research on another alternative -- geothermal energy. The U.S. is currently the world leader in electricity generated by geothermal steam, producing enough to light San Francisco, but it is a source used throughout the world as an alternative to fossil fuels.

Solar, in my opinion, is the ultimate source. We can heat water, heat and cool buildings, and produce electricity with it. It is a universally available source whose daily supply exceeds by 100,000 times the combined electrical generating capacity of all the nations of the world.

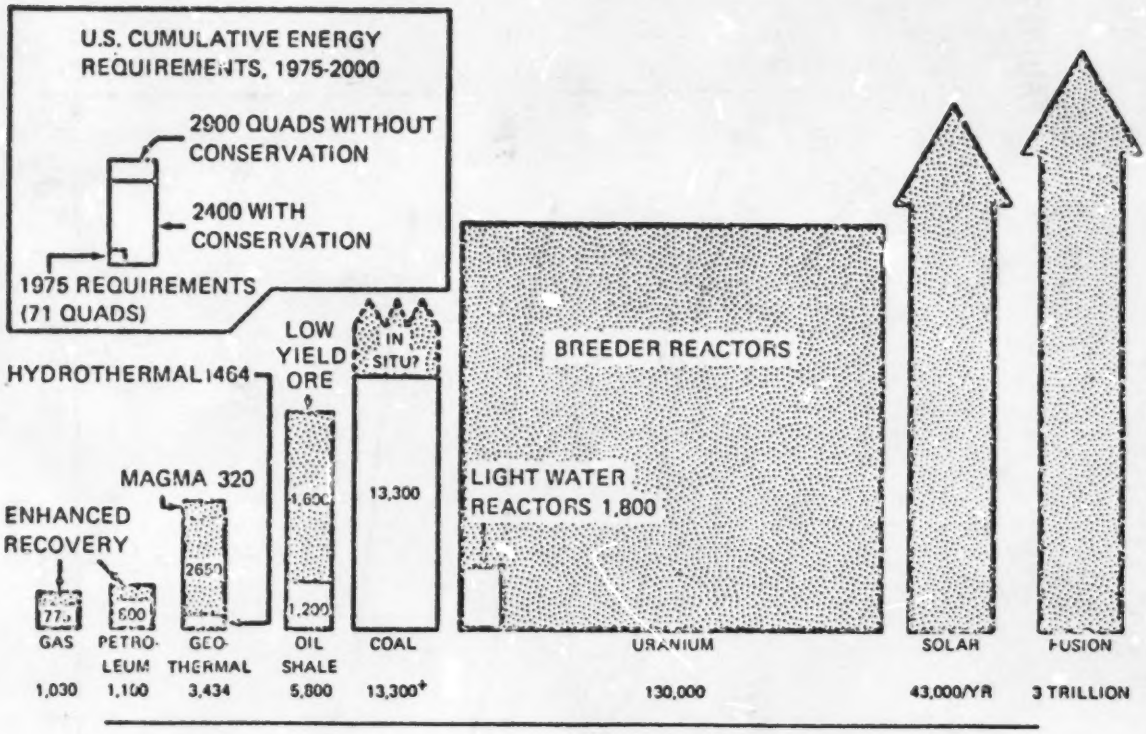
And still there are other alternatives: ocean thermal gradients, ocean currents, pyrolysis of solid wastes, methane from sewage, energy from the biomass, and the gravitational energy of the tides. All must be studied, since our situation is so critical that we cannot afford to overlook even the small potential contributors.

By way of summary, the large-scale energy sources that must be developed to assist coal in taking the place of future declines in oil and gas supplies and to provide for any future increases in energy consumption appear unlikely to make major contributions to our nation's supplies much before the end of this century. The lead times required for commercial impletation are very long and significant use of some sources requires technologies not yet in hand. Fortunately, we have been given two things: sufficient advanced warning to develop new sources for the future and enough coal and uranium to get us there. In the near-term our only choice appears to be to conserve energy in every way we can and buy OPEC oil.

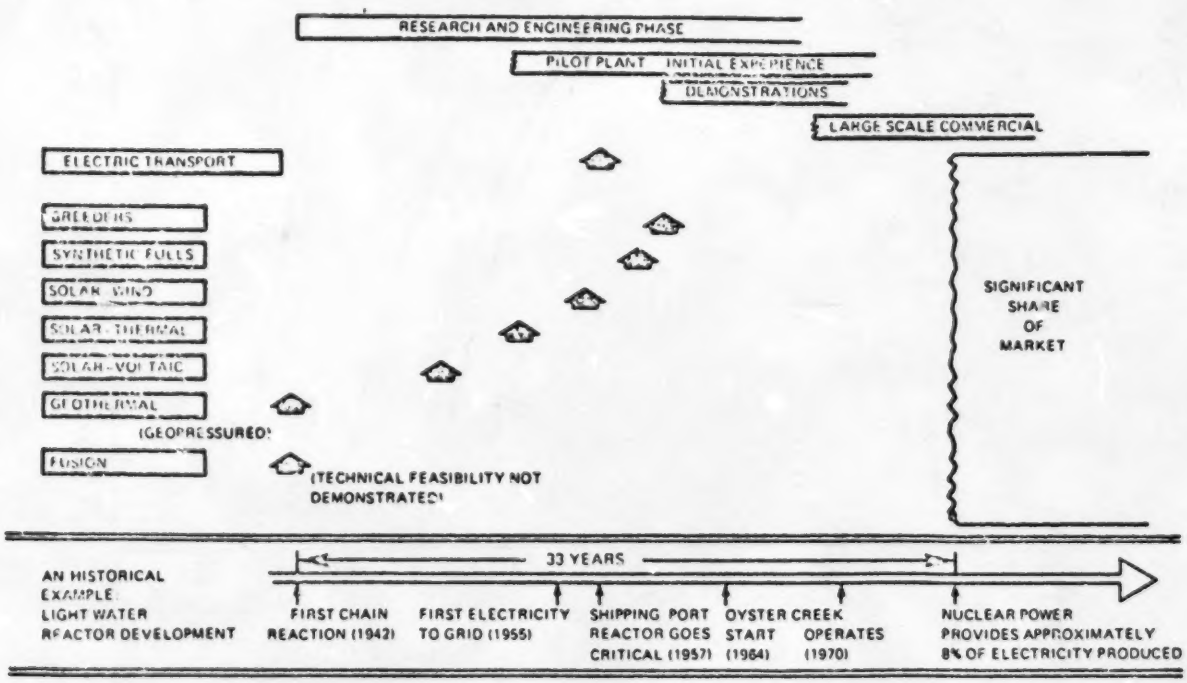
United States Energy Demand
By Fuel Consumed



ENERGY AVAILABLE AND REQUIREMENTS IN QUADS (10^{15} BTU) SHOWN GRAPHICALLY BY AREA



Potentially Recoverable Domestic Energy Resources



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INSCHO, F. Paul (1979): Hiwassee College, Madisonville, TN 37354 (615-442-2128)
KUCHERA, John (1979): Northern Oklahoma College, Tonkawa, OK 74653 (405-628-2581)
MILTON, Nina (1978): St. Petersburg Junior College, St. Petersburg Campus, St. Petersburg, FL 33733 (813-544-2551)
MINTER, Ann P. (1980): Roane State Community College, Harriman, TN 37748 (615-354-3000) (615-483-7124)
SIMS, Joyner (1979): Chipola Junior College, Marianna, FL 32446 (904-482-4935)
SINK, W.G. (1978): Davidson County Community College, Lexington, N.C. 27292 (704-249-8186)

Region III — Midwestern States

Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin

Midwest Regional Vice-Chairman (1978): Cullen Johnson (1978): Cuyahoga Community College, Western Campus, Parma, OH 44130 (216-845-4000)
BURNS, Ralph G. (1980): East Central Community College, Union, MO 63084 (314-583-5193)
CLOUSER, Joseph L. (1978): Wm. Rainey Harper College, Palatine, IL 60067 (312-398-4300)
ELKINS, Dean I. (1980): Henderson Community College, University of Kentucky, Henderson, KY 42420 (502-827-2867)
GREENBURG, Elliott (1980): Prairie State College, Chicago Hts., IL 10411
HITTEL, David (1980): Bay de Noc Community College, Escanaba, MI 49829 (906-786-5802)
KOCH, Frank (1979): Bismark Junior College, Bismark, ND 58501 (701-223-4500)
MALIK, Virginia (1978): Cuyahoga Community College, Western Campus, Parma, Ohio 44130 (216-845-4000)
REDMORE, Fred (1978): Highland Community College, Freeport, IL 61032 (815-233-6121 Ext. 331)
ROBIN, Burton (1979): Kennedy King College, 6800 S. Wentworth Ave. Chicago, IL 60621 (312-962-3200)
SCHULTZ, Dorothy (1979): Jackson Community College, Jackson, MI 49201 (517-787-0800)
SOSINSKY, Jack (1977): Loop Junior College, Chicago, IL 60601 (312-269-8056)
SUSSKIND, Tamra (1979): Oakland Community College, Auburn Hts., MI 48057 (313-852-1000)
WEISSMANN, Katherine E. (1980): Charles Stewart Mott Community College, 1401 East Court St., Flint Michigan 48503 (517-845-3670)
WINKELMAN, John (1978): Illinois Valley Community College, LaSalle, IL 61354 (815-224-6011)
YODER, James (1979): Heston College, Heston, KS 67062 (316-329-4421)

Region IV — Eastern States

Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Virginia, Vermont, West Virginia

Eastern Regional Vice-Chairman (1978): Paul Santiago (1978): Harford Community College, Bel Air, MD 21014 (301-838-1000) Ext. 252
ADAMS, David L. (1980): North Shore Community College, Beverly, MA 01915 (617-927-4850)
AYER, Howard A. (1980): Franklin Institute of Boston, Boston, MA 02116 (617-423-4630)
BERKE, Thomas (1978): Brookdale Community College, Lincroft, NJ 07738 (201-842-1900)
Mother Bohdonna (1980): Manor Junior College, Jenkintown, PA 19046 (215-884-2361)
BROWN, James L. (1979): Corning Community College, Corning, NY 14830 (607-962-9242)
CHERIUM, Stanley M. (1979): Delaware County Community College, Media, Pennsylvania 19063 (215-353-5400)
CLEVENGER, John V. (1979): Lord Fairfax Community College, Middletown, Virginia 22645 (703-869-1120)
CUCCI, Myron W. (1978): Monroe Community College, Rochester, NY 14623 (716-442-9950)
FINE, Leonard W. (1980): Housatonic Community College, Bridgeport, CT 06608 (203-336-8201)
HAJIAN, Harry G. (1978): Rhode Island Junior College, 199 Promenda Street, Providence, RI 02908 (401-311-1500)
JEANES, Opey J. (1979): John Tyler Community College, Chester, VA 23831 (804-748-6481)
SOLLIMO, Vincent (1979): Burlington County College, Pemberton, NJ 08068 (609-894-9311), Mail to Box 2788, Browns Mills, NJ 08068
STEIN, Herman (1980): Bronx Community College, City University of New York, Bronx, New York 10453 (212-367-7300)
VLASSIS, C.G. (1979): Keystone Junior College, LaPlume, PA 18440 (717-945-5141)
WILLIAMS, Thelma (1978): New York City Community College, 300 Jay Street, Brooklyn, NY 11201 (212-643-8242)
ZDRAVKOVICH, Vera (1980): Prince George's Community College, Largo, MD 20870
ZORANSKI, Ed (1980): Atlantic Community College, Mays Landing, NJ